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Control of Spillage of Hazardous Polluting Substances

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27 Abstract

An evaluation of the water quality aspects germane to the spillage of hazardous polluting substances is developed. Emphasis is placed on definition and classification of chemical materials; the nature of the sources of spillage and past experience; and analysis of the relative threat to water quality offered by such substances; a review of presently available detection, control, and removal technology; relationship to water quality standards; and the relevant administrative, enforcement, and cost recovery aspects. Over 800 chemical substances were evaluated as to their annual production and transport quantities, their critical concentration in the aquatic environment resulting in water quality impairment for the several beneficial water uses, detection limits (both field and laboratory), and the control and removal methods presently available or potentially practicable. Over 250 chemicals and compounds, generally those in large scale production and utilization, are priority ranked in order of relative threat to water quality in terms of annual production/sales, intrinsic hazard to water quality, transport mode, and past statistical accident frequency. Recommendations are presented regarding future research and development efforts aimed at mitigating damage and a consensus of informed parties is presented relating to the need for additional legislation. ~~This report fulfills Contract No. 14 12-866, between the Federal Water Quality Administration and the Pacific Northwest Laboratories, Battelle Memorial Institute.~~

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The right of a citizen to bring an action to abate pollution without showing specific damage to himself ought to be granted under the Refuse Act in both State and Federal law. The _qui tam_ theory should not be expanded. Rather, class action rights should be authorized with no monetary rewards provided to the plaintiff, other than the recovery of costs when he prevails. This is particularly true when the prosecution of hazardous polluting substances (spill cases) is so inadequate at both the State and Federal level. Any damages recovered would go into funds established to effect environmental restoration in the event cleanup or restoration at a specific spill site were impossible or undesirable.

CONTROL OF SPILLAGE
OF HAZARDOUS POLLUTING SUBSTANCES

by

G. W. Dawson, A. J. Shuckrow,
and W. H. Swift

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for the

FEDERAL WATER QUALITY ADMINISTRATION

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FEDERAL WATER QUALITY ADMINISTRATION

REVIEW NOTICE

This report has been previewed by the Federal Water Quality Administration and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Federal Water Quality Administration, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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Recommendations are presented regarding future research and development efforts aimed at mitigating damage and a consensus of informed parties is presented relating to the need for additional legislation.

This report was submitted in fulfillment of Contract No. 14-12-866, as amended, between the Federal Water Quality Administration and the Pacific Northwest Laboratories, a Division of Battelle Memorial Institute.

Key Words: Hazardous polluting substances, chemicals, spills, enforcement, cost recovery, water quality, detection, monitoring, countermeasures, environmental fate, acute discharges, accidents, critical concentrations.

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SUMMARY

Public Law 91-224, The Water Quality Improvement Act of 1970, indicates public and Congressional concern regarding hazardous polluting substances. Further, the usage of the latter term in the law suggests questions in the public mind as to definition and the magnitude of hazards involved.

At present there are a multiplicity of classification systems for hazardous materials. Only one of these adresses itself specifically to the water quality aspects of hazardous materials, and none of the systems provides a mechanism for developing an understanding of the relative threat various materials pose to water quality. Consequently, a priority rating system and a new classification system have been developed. The former evaluates the lowest concentration range at which a substance impairs one of the beneficial uses of water, the quantity shipped annually by each mode of transport, and the probability of an accidental spill to surface waters for each transport mode. The resulting rating number can be interpreted as the volume of water potentially threatened by a pollutant annually. A compound's ranking is then representative of its potential threat to water quality and, therefore, an indicator of the priority it should receive with respect to other substances.

To facilitate data handling, a computer program was employed to perform the computations involved in ranking more than 250 compounds or classes of compounds for which production figures were available. It is felt that the priority and classification systems offered here will provide a sound basis from which to structure the efforts which are recommended for establishing a satisfactory response system.

The classification system is derived on the premise that once a spill has occurred, detection at levels below the toxicity threshold and the ability to neutralize the spill to levels below toxic values are the two major concerns. Each of four water quality parameters--human toxicity, fish toxicity, plant toxicity, and aesthetic effects--are considered individually.

A tabulation of more than 800 materials was developed to collect the data for the classification system. The table details published threshold limits for the four water use

parameters as well as physical properties, field detection limits, biological oxygen demand data, and availability of control or damage mitigation techniques for each compound. This table illustrates the numerous information gaps in current knowledge on hazardous substances as related to water quality.

In support of the decisions made in establishing these systems and as a mechanism for putting them in better perspective, the study includes an examination of the factors involved in the formulation of either the priority ranking or classification systems.

Present contingency plans on the national, regional, state, and local levels were studied and deemed inadequate for most materials other than oil. Industrial response plans in operation or planned were found to contain certain features superior to the National Oil and Hazardous Materials Contingency Plan. The former provide for more immediate response with a higher level of technical expertise specific to the substance involved. The latter, and its regional subplans, appear more oriented toward the management and communications aspects. The need for a blend of both public and private sector plans is apparent.

Existing or possible procedures for neutralization of spills were also reviewed. In most cases these were found to be inadequate or potentially more damaging than the original contaminant. The 220 soluble substances ranked in the priority system were assigned response procedures. In most cases, the recommended action involved techniques which have not been tried in a free water environment.

The need for legislation to impose liability for the cost of removal is reviewed along with the appropriate measures for enforcement and recovery of costs incurred by the United States if removal is undertaken by the United States.

In general, the present defensive posture against environmental degradation and public health damages resulting from spills of hazardous materials has been found to be unnecessarily weak in light of the position that can be achieved through properly channeled efforts. Prevention of spills remains the first and most important line of defense. In many instances very little can be done to control a spill once it has occurred. This does not, however, imply that improved understanding of spill behavior and effects and more sophisticated contingency and response planning should not be pursued vigorously.

RECOMMENDATIONS

Research and Development Requirements

The detailed study of acute spills of hazardous materials undertaken by Battelle-Northwest and outlined in the following report points to the need for research in several areas.

While efforts must proceed in all areas, it is evident that field detection and countermeasures must take precedence. This would entail an initial approach to review all existing techniques and procedures, a followup investigation to evaluate available methods that have not been tested in a free aquatic environment, and finally, research into new ideas that could be employed but have not been attempted before.

Specific research and development needs in these areas include:

- Collection of seasonal infrared background spectra for selected river basin sites.
- Development of new and more sensitive analytical tests for use in the field.
- Collection of available field and laboratory detection techniques and procedures into an automated information bank with frequent updating and output in the form of a manual to be widely distributed to spill response personnel.
- Examination of the effects of precipitation and neutralization countermeasures on the aquatic environment.
- Investigation of new application techniques to utilize carbon sorption processes for the removal of soluble organics from free waters.
- Development of techniques for the removal of dense pollutants and flocs from free waters.
- Development of new techniques for the ultimate disposal of hazardous materials spilled into the aquatic environment.

- Collection of data for and formation of an information bank detailing the spill countermeasures presently deemed adequate and feasible for frequent publication in a manual to be distributed to spill response personnel.
- Review of existing dispersion predictive models and time of travel data for field application.
- Development of new dispersion predictive models and time of travel data where information is not available.
- Study of solid phase materials as repositories for contaminating materials in the aquatic environment, including organic sorption and ion exchange.
- Investigation of parameters involved for predicting bioconcentration of hazardous materials.
- Definition of necessary factors for and development of a comprehensive environmental fate testing program.
- Development of remote instream monitoring devices for detection of toxic materials possibly utilizing advanced chemical sensing devices or physical-biological monitoring of aquatic species *in situ*.
- Mapping of high frequency spill areas, high water use areas, and areas exposed to highly toxic materials for purposes of siting monitoring stations.

Program Recommendations

To better fulfill the present research requirements and long term program objectives related to the spill of hazardous materials, the following policy and program changes are recommended:

- The priority ranking system and the classification scheme devised in this program should be maintained and frequently updated to focus attention to high priority materials and aid in regulatory decisions.
- A new reporting system should be devised to optimize possible information flow through regional agents capable of immediate interaction with reporting personnel.

- Results of the reporting procedure should be transcribed into a form amenable to transfer into an automated retrieval system such that multipurposed probes can be made to establish causitive trends and response efficiencies.
- New, highly hazardous products should be subjected to environmental fate testing and subsequent classification prior to issuance of permits for bulk transport.
- Hazardous materials policy and research and development responsibility should be handled by a single government agency.
- The responsible agency should oversee development of a hazardous materials response center with capabilities for response to any hazardous material related incident threatening any part of the total environment as well as for aiding management and regulatory decisions.
- The National Contingency Plan should be restructured to provide for maximum industrial participation and a sound funding base.

INTRODUCTION

Objectives and Scope of Study

This report has been prepared for the Federal Water Quality Administration by Battelle-Northwest to provide a critical review of available knowledge on the water pollution problems caused by spills of hazardous polluting substances, a survey and evaluation of existing control methods, and recommendations for a program to develop new or improved methods for controlling spills of such materials. The study was limited to a six-month working period and did not include radioactive materials, oil, or chemical and biological warfare agents.

Since this effort represents the first known attempt at systematically analyzing the full scope of problems presented by the accidental spillage of hazardous materials in terms of potential water quality impairment, the data base and information sources in general were found to be inadequate, widely scattered, and the problems poorly defined. Thus, considerable effort was expended to establish the needed definitions and to interpret and link together related information within the context of the program objectives. In the majority of instances of past spills or in contacts with personnel expected to have relevant information, it was clear that although concern had been expressed on the water quality impairment aspects of spills, limited prior consideration has been given specifically to means of control and restoration. In a number of instances relevant data, though possibly existing, could not be retrieved due to the short time available for this review or, in certain cases, due to the methods of information storage. In other instances, desired data does not exist at present.

Recognizing the state of knowledge in the control of spillage of hazardous polluting substances, this report provides the following specific contributions toward solution of the problems involved:

- All known hazardous materials classifications, listings, and ranking systems have been combined and summarized from the standpoint of potential for water quality impairment.

- Information intrinsic to more than 800 substances has been compiled from a number of sources and summarized in terms of factors relating to potential water quality impairment.

- A rational, and internally consistent, potential threat evaluation and ranking system has been developed and applied to more than 250 substances for which production data are available. All of these are major articles of commerce.

- The nature of the sources of spills is reviewed.

- The present state-of-the-art in detection, control and removal is reviewed for more than 250 materials.

- Examples are presented to indicate the behavior that hazardous polluting substances might exhibit on release along with indication of some of the more subtle and less quantifiable factors involved.

- Contingency and response plans, both public and private, are discussed and analyzed in search of improved systems.

- Regulatory and enforcement aspects of the control of spillage of hazardous polluting substances is reviewed, with viewpoints presented from both state and federal levels.

- Recommendations are made in all the above areas insofar as existing information is available. Where this latter is not available, the gaps are pointed out along with suggestions for improvement in the information base.

The Water Quality Improvement Act of 1970

In view of the fact that this program was conducted in part due to the impetus of the Water Quality Improvement Act of 1970, Public Law 91-224, signed by the President on April 3, 1970, it is appropriate to quote relevant sections:

> "Sec. 12. (a) The President shall, in accordance with subsection (b) of this section, develop, promulgate, and revise as may be appropriate, regulations (1) designating as hazardous substances,

> other than oil as defined in Section 11 of this Act, such elements and compounds which, when discharged in any quantity into or upon the navigable waters of the United States or adjoining shorelines or the waters of the contiguous zone, present an imminent and substantial danger to the public health or welfare, including, but not limited to, fish, shellfish, wildlife, shorelines, and beaches; and (2) establishing, if appropriate, recommended methods and means for the removal of such substances..."

The law further states that:

> "(g) The President shall submit a report to the Congress, together with his recommendations, not later than November 1, 1970, on the need for, and desirability of, enacting legislation to impose liability for the cost of removal of hazardous substances discharged from vessels and onshore and offshore facilities subject to this section including financial responsibility requirements. In preparing this report, the President shall conduct an accelerated study which shall include, but not be limited to, the method and measures for controlling hazardous substances to prevent this discharge, and the most appropriate measures for (1) enforcement (including the imposition of civil and criminal penalties for discharges and for failure to notify), and (2) recovery of costs incurred by the United States if removal is undertaken by the United States. In carrying out this study, the President shall consult with the interested representatives of the various public and private groups that would be affected by such legislation as well as other interested persons..."

To meet the requirements stipulated in Public Law 91-224, a number of general needs are readily identifiable:

- A definition and understanding of the scope of the term "hazardous polluting substances" as it relates to water quality;
- An understanding of the nature and magnitude of the potential problem presented by substances so defined;
- An understanding of the present state-of-the-art in controlling and mitigating damage, and in removing such materials from the environment;

- An overview of the technical and judicial aspects relating to enforcement and cost recovery problems;
- A sense of priority-of-concern in view of the almost unlimited scope that could be encompassed by the term "hazardous polluting substances;"
- A knowledge of the various contingency and response plans, both public and private, currently in effect and the extent to which they relate to hazardous substances other than oil.

This report is aimed at fulfilling these needs.

Nature and Definition of the Problem

General Considerations

Considerable attention has recently been addressed to the potential threat posed by hazardous materials to public health and safety and to environmental quality. Although by far the greatest attention in the past has been focused on the threat to human life and property, increasing public interest is coming to bear on the threat to environmental quality. This latter awareness and concern is exemplified by the public response to the closely related oil spillage problems and goes beyond the realm of safety and economics into that of aesthetics and the quality of life in general.

Recognizing that spillage of any material is by definition an infrequent rather than a continuous occurrence, it is important to place the problem of spillage of hazardous polluting substances in its proper perspective vis-a-vis other water pollution issues which are generally chronic in nature. Although these latter are constantly apparent, officials with overview responsibility for water quality standards, and for regional enforcement and problem solving, regard the acute spills as a major problem to which increased attention should be given. Of the many water quality problems that exist, acute spills of hazardous substances ranks in the top ten.

Spills of hazardous polluting substances are of special concern because of at least three factors. Firstly, by their very nature, spills occur unexpectedly and with an element of surprise. Hence, the resulting action taken by responsible officials, private and public, must often be effectively carried out under crisis conditions. Secondly, advance planning, in the sense analogous to fire protection, is difficult due to the extreme diversity of types of substances that might be spilled, the nature of resources threatened, and the variety of control and damage mitigation measures that could possibly be envoked. The immediate operational information needs are hence enormous. Finally, in contrast to the more common chronic water pollution problem of continuous release of a variety of wastes, the effects of high concentration or shock releases via the spill mechanism are far less well understood, although much basic data is available from prior work directed principally at other concerns. Aquatic organisms to some degree become adapted to continuous low levels of pollution, but can be totally decimated by a severe, but transient, degradation of water quality.

Technical Dimensions

Many materials "normally" considered as hazardous are significant and beneficially important factors in modern society. An even larger number of substances not "normally" considered as hazardous, can have highly deleterious effects if accidentally released to receiving waters. As a result, balanced judgment needs to be employed even in defining "hazardous polluting substances." The fact that some risk is inherent, and indeed, is beneficial, in all human activities must be recognized. Unfortunately, quantifications of benefits derived from accepting a given risk are far better understood than is the nature and extent of the risk itself. Therefore, to reach an orderly and realistic understanding of the problem posed by hazardous polluting substances, and to establish a reasonable sense of priorities, it is necessary to explore a wide variety of relevant aspects, factors, or dimensions of the problem.

At the outset, it is vital to recognize that the term "hazardous" has two distinct connotations. The first relates to the intrinsic properties of the substance itself, i.e., the amount of damage that could be rendered to a resource, in this case, water quality by a unit quantity of the substance. The second relates to the extrinsic factor of degree of exposure of the resource to the hazard. This latter aspect includes consideration of such elements as quantity, behavior, delivery mechanism, and nature of the resource (water body) itself.

To better quantify the overall problem, the program herein reported has been organized along the lines of certain key technical factors or dimensions involving the above connotations. Since these factors enter into all aspects covered in the program, and affect the level of threat, it is appropriate to highlight them at the outset.

Quantities of Substances Involved: Since hazard potential is a direct function of the amount of material present, and hence potentially spilled, consideration must be given to gross annual production of given substances, the quantities in the transportation system (an environment that is varied and difficult to control), and the captive in-plant consumption or conversion of a given substance.

Critical Impairment Concentration: This is both an intrinsic property of the given material, and a property of the water subject to quality impairment. Consideration must be given to all the beneficial uses of water, i.e., domestic and industrial water supplies, aquatic life, agricultural, recreational and aesthetic, and navigational. Depending on the water use, the quality impairment resulting from a given spill can range from substantial to inconsequential.

Mode of Transport: Since materials in the process of being transported and the vehicles themselves are exposed to a wide range of environments and stresses, consideration must be given to the mode of transport as it affects the probability and magnitude of spillage. Modes of transport of significance in the water quality context include waterborne, rail, motor carrier, and pipeline.

Containerization and Packaging: The quantity of substance within a given envelope obviously has bearing on the magnitude of potential spill and hence the level of damage possibly inflicted. Hence both the maximum uncompartmented quantity and the inherent container integrity are significant.

Storage and Handling Practices: By no means do all spills originate from transportation accidents. Stationary sources such as tank farms, lagoons, storage and disposal facilities, etc., can be major sources.

Behavior on Release: Knowledge of the physical and chemical behavior of a hazardous polluting substance upon release is of utmost importance. This behavior affects not only the nature and extent of damage, but also the practicability of instituting control and removal measures.

Concurrent Hazards: Many materials have substantial associated hazards other than those relating to water quality. Knowledge of these must be complete as they may significantly influence decisions made in the field and may affect the nature or determine the practicability of response plans and systems. Such factors include fire, explosion, exothermic or endothermic reactivity with adjacent cargoes or with water, and vapor irritant problems.

Persistence or Duration of Water Quality Impairment: Depending on the nature of the receiving waters, water chemistry, bottom sediments and aquatic life, as well as upon the specific physical and chemical properties of the material in question, certain substances can be highly persistent. The insecticide, DDT, is a case in point. Such persistence suggests that removal and restoration measures can and should be taken over an extended period of time.

Potential for Biological Modification and Concentration: Only in recent times has it become apparent that aquatic organisms are capable of biologically modifying and concentrating chemical materials through successive steps in the food chain. Thus, materials in water may occur initially at subhazardous concentrations, but biological activity can lead to hazardous levels. Cases in point are mercury, other heavy metals, and many pesticides.

Detectability: The relative hazard of an unseen or undetected pollutant is inherently greater than that of those readily observed. Since detection is one of the initial needs in responding to a spill, a thorough understanding of the associated analytical problems is needed.

Present Status of Other Hazardous Materials Programs

Concern for hazardous materials is by no means a new issue and various governmental and industrial organizations have long been involved in the public safety and property protection aspects.

In the past, design, regulatory, and contingency planning activities have, on all fronts, been largely and justly devoted to the protection of life and property and minimal attention has been given specifically to the water pollution aspects of spills. The National Academy of Sciences(27) has reviewed the hazards associated with bulk waterborne transport of hazardous materials. Water pollution aspects have been touched on in the above work, but the main thrust has been toward other hazards and the commonalities involved have been limited.

Similarly, the Department of Agriculture regulates the licensing and use of a wide variety of agriculture chemicals including Class B Poisons. The U.S. Atomic Energy Commission fulfills a similar function in connection with radioactive materials (not considered within the scope of this effort). The Department of Health, Education and Welfare promulgates drinking water standards relevant to a wide variety of potentially hazardous substances from a public health standpoint. The Department of Defense is concerned with control of chemical and biological warfare agents which were excluded from consideration in this program.

In the private sector, individual companies, industrial associations, insurance organizations, and cooperative groups have, to various degrees, attacked the problem. In general, however, it is fair to state that consideration of the water pollution/quality aspects of spills is relatively recent and has received less attention than the chronic waste discharge problems.

With the advent of the TORREY CANYON oil pollution incident in early 1967, the Federal Government became increasingly concerned with the spillage not only of oil, but also of other hazardous substances. This concern led to promulgation of a National Oil and Hazardous Materials Contingency Plan in 1968, later to be revised, refined and reissued in June 1970.(56) This plan is generally addressed to the oil spillage problem, primarily because more technical information is available in this field. However, the plan does establish a management framework readily capable of accepting additional technical input. One purpose of the work reported herein is to provide some of this information base.

In the event of a spillage incident, rapid communications are an essential to well-ordered and effective response. To provide this communications vehicle in support of the National Contingency Plan, the U.S. Coast Guard in cooperation with the Federal Water Quality Administration, the Office of Emergency Preparedness, the Department of Defense, and the Department of Health, Education and Welfare, has established a National Response Center and is in the process of developing an automated information system as a management and technical decision making tool.

Program Rationale

The program was conducted under the rationale outlined in Figure 1. Hazardous Materials Listings were gathered and screened to derive a definition of the term "hazardous materials." Having considered the criteria utilized in previous listings it was determined that any and all materials could be hazardous to the aquatic environment depending upon the concentration levels and water uses involved. Consequently, all materials were considered as hazardous materials. To limit the study to manageable size under such a definition, it was deemed necessary to develop a priority ranking formulation. Investigation of the parameters pertinent to such a priority ranking system revealed that a meaningful formulation could be derived from knowledge of the origin of spills and environmental complexities involved in pollutant interaction with the aquatic environment. The origin of spills as shown in Figure 1 was determined from three sources: transportation considerations, historical spill data, and stationary sources. Adequate data amenable to numerical formulation was available only from transportation considerations which were accumulated from review of federal regulations, container considerations, production statistics, and accident histories. Development of the ranking system is considered an important output of the program.

To complement the ranking system, a new classification system was also derived. This system addresses itself to the water quality considerations necessary should a response be made to ameliorate the effects of an acute spill. Present classification systems were reviewed, but found inadequate. To avoid the problems encountered by the previous systems, the new scheme was structured on a comparison of the environmental complexities involved with a pollutant spilled into the aquatic environment, the pollutants' detectability in that environment, and the availability of countermeasures to ameliorate subsequent damaging effects.

Judicious use of both the ranking system and the classification scheme should greatly aid in prevention efforts aimed at minimizing hazardous material spills. However, should a spill occur, contingency plans are required to handle the response mechanism. In light of this, present contingency plans from all sectors were analyzed and a review of past incidents was conducted to determine the deficiencies. Present enforcement and legal policies were also studied. Finally, after consideration of all these factors, a recommended contingency plan was devised.

As illustrated in Figure 1 the outputs of the priority system, the classification scheme, and the recommended contingency plan were then screened to develop the specific recommendations offered here by Battelle-Northwest. The actual data considered, outputs derived, and recommendations made follow in the text and appended material of this report.

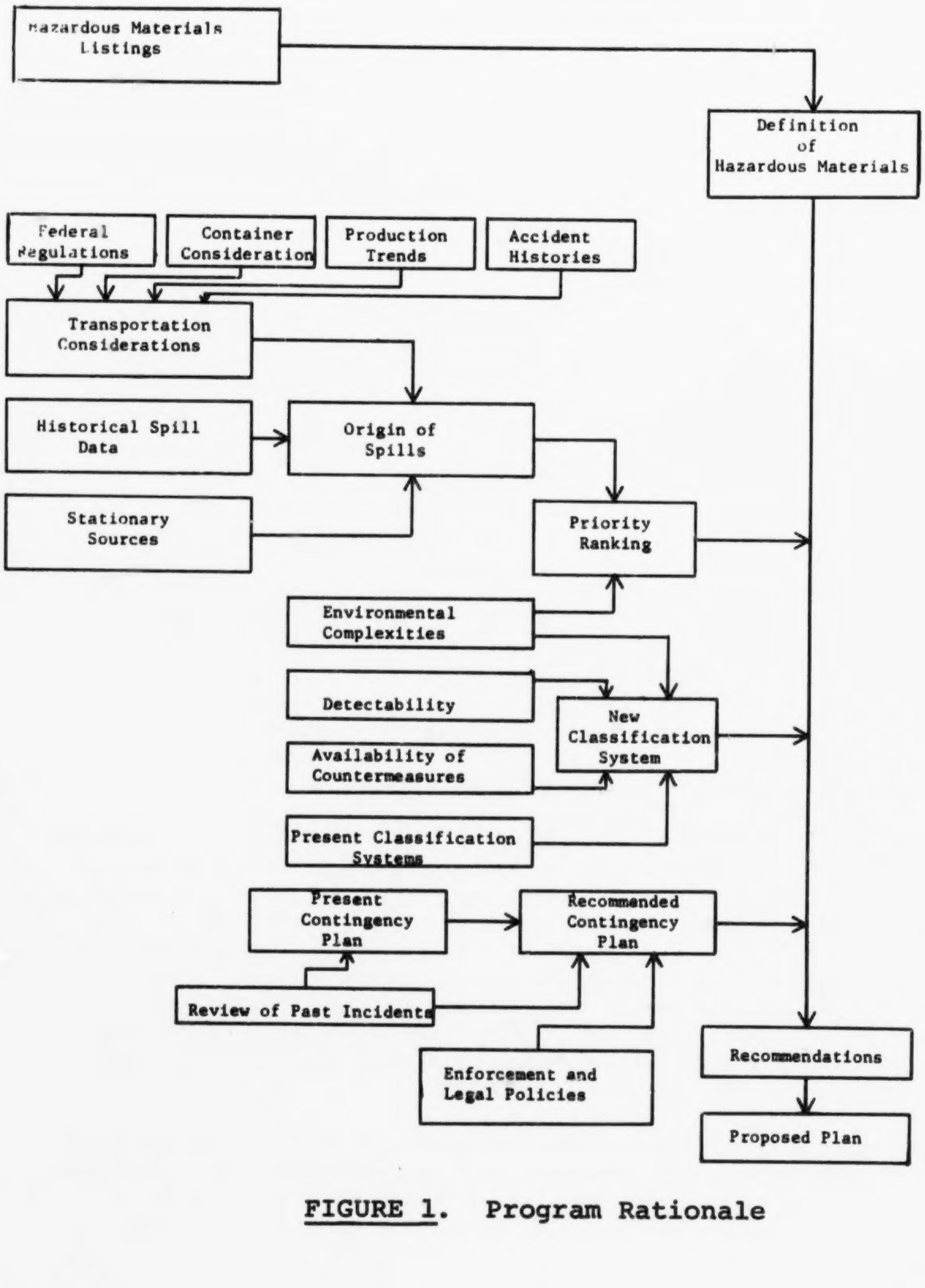

Hazardous Materials Listings
Definition of Hazardous Materials
Federal Regulations
Container Consideration
Production Trends
Accident Histories
Transportation Considerations
Historical Spill Data
Origin of Spills
Stationary Sources
Priority Ranking
Environmental Complexities
Detectability
New Classification System
Availability of Countermeasures
Present Classification Systems
Present Contingency Plan
Recommended Contingency Plan
Review of Past Incidents
Enforcement and Legal Policies
Recommendations
Proposed Plan

FIGURE 1. Program Rationale

CLASSIFICATION SYSTEMS

Brief

In evaluating the nature of hazardous polluting substance spills, it is apparent that all substances are hazardous to water quality depending upon the location, time and concentration of the spill. Consequently, there is a need to develop a sense of priority so that the optimum attention can be directed toward those substances which pose the greatest threat to water quality. It is also desirable to establish a classification system to categorize hazardous materials in relation to the availability of means for coping with spills of these materials into the aquatic environment. It was concluded that presently available classification systems do not adequately address themselves to the water quality aspects and consequently cannot fulfill the above needs.

To correct this situation, a numerical priority system has been devised that formulates numerical rankings on the basis of the total volume of water potentially threatened by a substance each year. Further, a classification system based on the inherent toxicity of a substance, the limits at which that substance can be detected in the field, and the availability of countermeasures for ameliorating damaging effects has been developed.

Need for Classification Systems

To establish which hazardous polluting substances deserve the greatest attention, a priority system must be developed to permit direct comparison of individual compounds in terms of the potential threat posed to water quality. A standard formulation is needed to avoid arbitrary decisions as to which materials are most significant.

In addition to the priority system, a classification system is needed to relate chemical properties to water quality parameters of interest. This second system would group chemicals having similar properties, thus permitting more efficient interpretation and evaluation.

It is not immediately obvious why these functions cannot be served by the presently available listings or systems. With existing systems, there is no direct relationship between the individual rankings for various categories and subdivisions. Many chemicals tend to receive widely variant rankings, i.e., methanol is tolerated by fish, but highly toxic to humans while the opposite is the case for nickel ammonium sulfate. This indicates that widely divergent conclusions could be drawn for the same compound if judged for different water quality parameters. A mechanism for combination of the parallel subsystems is desirable; however, ultimate integration of subdivisions requires the establishment of some method for comparing the impairment of water quality on an equivalent basis for each beneficial use.

Existing Classification Systems and Listings

Criteria upon which hazardous materials classification systems are based vary widely depending upon the intended purpose and ultimate use. Table C-1 of Appendix C contains a list of classification system criteria based on systems either currently used or those likely to be regarded as necessary to fully develop a more comprehensive system to cope with water quality threats. It is apparent that no one system presently can incorporate all of the possible criteria. However, to assess the magnitude of the effort required in attaining a desirable comprehensive system, the following discussion shows that system objectives and uses are critical considerations.

Presently, there are about 30 major classification systems being utilized by public and private agencies to categorize hazardous materials,(3) as listed in Table C-2 of

Appendix C. Since each system was designed for a specific purpose, they vary widely in their characteristics. An important preliminary consideration in the use of any system for a particular problem is identification of applicable criteria and the elimination of those which are unnecessary. When this is accomplished, an established plan can be accepted, or a new classification scheme can be derived. The important point is that no single system will suit all needs. Although some systems are available which attempt this to some degree, they are, in fact, collections of parallel systems. Thus, a system such as that of the National Safety Council(17) codes the severity and type of hazard, the required precautions, first aid procedures, flammability, flash point, toxicity, reactivity, skin response, and injury potential of industrial compounds; but each is separately coded with no subsystem integration to establish one set of symbols or a common nomenclature to signify all the pertinent information.

Similarly, the National Academy of Sciences(27) presents a collection of grade listings for fire hazard, vapor irritation, solid or liquid irritation, poison rating, human toxicity, aquatic toxicity, aesthetic effect on water, reactivity with other chemicals, reactivity with water, and stability. The "Chemical Transportation Safety Index"(19) utilizes this format to grade compounds for the classification and degree of risk involved, advisable precautions, hazard to life, first aid procedures, fire danger and control, stability, and clean-up procedures. Many systems for labeling chemicals in transit employ only the first rating. A colored label is used to denote the categories: flammable liquid, flammable compressed gas, flammable solid, oxidizing material, corrosive liquid, nonflammable compressed gas, Class A poison, Class B poison, etiological agent, cryogenic liquid, radioactive materials, explosive, or molten materials. Such a classification carries a set of precautions and emergency procedures that relate to each category. The "Hazardous Commodity Handbook"(36) published by the National Tank Truck Carriers, Inc. and the Manufacturing Chemists Association's "Guide to Precautionary Labeling of Hazardous Chemicals"(35) utilize this approach. The output from these systems is often a manual similar to the MCA "Chem-Card Manual," a transportation emergency guide. After the hazards are defined for each material, responses are detailed for three possible accidental situations--spill or leak, fire, and explosion.

These examples serve to illustrate that the existence of a large number of criteria and parameters has forced the separate classification of materials for each criterion and parameter considered. Combination of classifications can be achieved to some degree as in the NAS(27) listing which groups the vapor, liquid, and solid irritant; and poison rating under the larger heading of "Health." Human and aquatic toxicity, and aesthetic effect on water are grouped under "Water Pollution," while stability and reactivity data are grouped under "Reactivity."

Critique of Classification System Requirements Related to Water Quality

In dealing with the spill of hazardous materials into water, classification systems must be focused on water quality parameters. Of the systems investigated, only the NAS tables(27) attempt this approach with the "Water Pollution" division subdivided into "Human Toxicity," "Aquatic Toxicity," and "Aesthetic Effects." "Human Toxicity" figures are listed as ingestion limits.

With the above background in mind, it is essential that any effective classification system developed should encompass at least the following aspects regardless of intended use:

- Classification systems should be action oriented, i.e., be a prime determinant in regulatory, operational, and research and development direction activities. The priority system should form the outline of approach for research programs on specific compounds, and both it and the classification system should be employed to group compounds for administrative and regulatory purposes. In some instances, such as the determination of special handling permits, the classification scheme should be integrated into a single grading. One group may represent chemicals which should not be shipped in bulk on barges because of potential major impairment of water quality while another may represent compounds with no shipment restrictions placed on them. The exact nature of the related regulations can be structured, modified, and restructured at the option of the controlling agency once the category limitations have been defined.

- Classification systems should be as quantitative as possible and should be designed to assist day-to-day operational and planning functions.

- Since there are a wide variety of water uses and a near endless number of materials that could be classified or designated as hazardous polluting substances, it is essential that any truly useful system express a strong sense of priority-of-concern. This expression is intrinsic to the definition itself. History well reports that when a broad subject, such as that discussed here is approached, little penetration toward problem solutions is achieved unless action is initially concentrated in areas of greatest concern.

- As pointed out in the introduction, the term "Hazardous" as applied to polluting substances, has two distinct elements: firstly, the intrinsic nature of a given substance itself and secondly, the frequency and severity of exposure of waters to quality impairment. No present classification system includes this "exposure" consideration either from water quality or from other aspects.

To circumvent the shortcomings of present systems, regardless of their intended application, and to extend their consideration to water quality aspects, considerable thought and effort has been given to the total water quality hazard system--intrinsic and extrinsic. The initial product of this effort is presented in the following pages.

Recommended Water Quality Classification Systems

To satisfy the functional needs for classification of hazardous materials in the context of water quality, two separate systems have been derived in the present study. Each evaluates parameters unique to its proposed usage and one parameter common to both systems. The common element is the concept of critical concentration.

Four major water quality parameters have been defined: human toxicity, aquatic toxicity, aesthetic effect, and plant toxicity. A critical concentration was then defined for each of the parameters as the minimum concentration of a substance which would produce detrimental effects. In the case of human toxicity, the critical concentration value has been taken as the maximum allowable concentration in domestic water supplies. For aquatic toxicity, depending upon the availability of data, a combination of T_{Lm} values and threshold values for effects on fish was used in defining the critical concentration. Critical concentrations for aesthetic effects were selected on the basis of the threshold detection limit for normal human perception in drinking water supplies. Finally, in the case of plant toxicity, the critical concentration represents the maximum concentration tolerated by cultivated crops without an appreciable loss of product yield. The data available for such determinations appears in Appendix B.

Priority Classification System

The primary consideration in the development of this ranking system was the potential threat posed to water quality by various compounds. Consequently, a common unit representing that threat was needed so that evaluation of the relative threat of each substance yields a comparative basis upon which rankings can be formulated. After a thorough review of the available data base, it was determined that the volume of water annually threatened by each compound could be used. To determine that volume, it was necessary to establish the quantity of each material produced and sold, the critical concentration, and the fraction spilled into the aquatic environment.

Since the impairment of any of the four major water quality parameters is unacceptable, all water uses were considered to be of equal value and thus the need for weighting factors was eliminated. Thus, the critical concentration used in the priority system for each compound was the lowest concentration which would impair any one of the four water quality parameters.

The development of the ranking system is based on the premise that the priority assigned to any material with regard to water quality is dependent upon two factors: the quantity available for spillage to a body of water, and the acute hazard associated with the material.

The volume of a material spilled is defined as:

$$Q = QI \left[(p_w f_w) + (p_r f_r a_r) + (p_t f_t a_t)\right]$$

where QI = quantity of material shipped (if shipping figures not available, sales or production quantity used)

Q = quantity of material potentially introduced into water w = water traffic

r = rail traffic

t = truck traffic

p = probability of accident

f = percent of total quantity shipped by a given transport mode

a = adjustment factor to reflect probability of a spill reaching a water course.

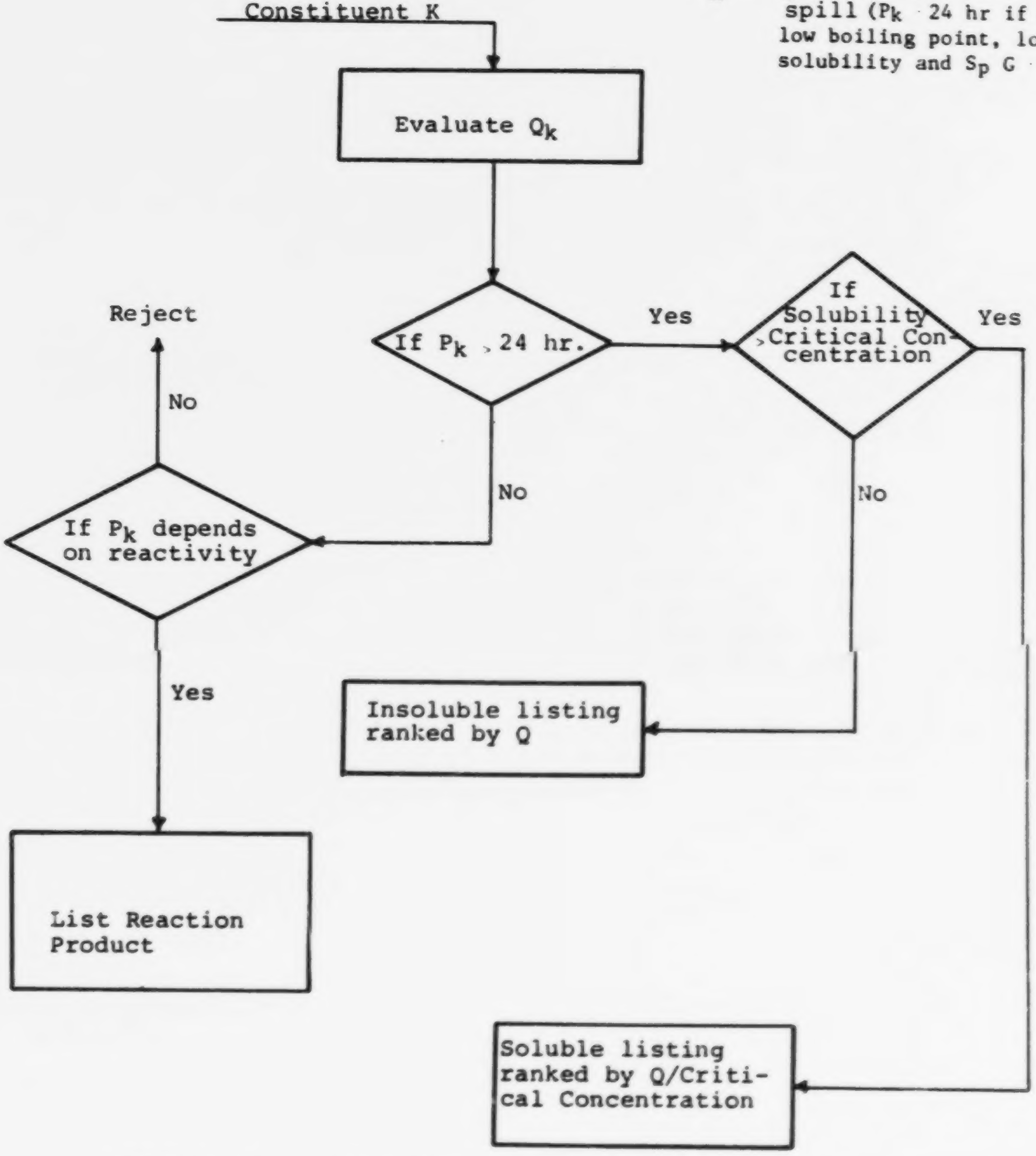
Pipeline transport presently pertains only to a small fraction of hazardous materials and is therefore not included in the present formulation. In the future, this transportation mode can readily be included in the formula therefore pointing out the inherent flexibility of this system.

With the Q factor determined, ranking is achieved by dividing Q by cc, the master critical concentration. This quantity, Q/cc superficially represents the volume of water potentially threatened by a compound in a year of shipments. That is, it would require this volume of water to dilute the annual quantity of a compound potentially spilled in water to a concentration less than the critical concentration.

Several modifications of this system would be desirable if the required data were available. One would weight probability factors by an additional factor denoting the relative size of shipments of a compound carried by each of the three transport modes. It could also be modified to reflect container integrity under impact stresses common to accident conditions. Unfortunately, these data are not presently available.

It is recommended that detailed studies be initiated to evaluate container integrity under impact and the distribution of container and shipment size for individual substances. This will allow for a more accurate formulation of the threats posed by materials to water quality.

In employing a technique of this sort, it is necessary to have several decision steps to deal with water insoluble substances. A flow diagram illustrating the steps in the ranking system is presented in Figure 2. Two such decisions were utilized. The first was a simple persistence judgment which rejected all low density, low boiling (b.p. <35°C) compounds with a solubility lower than its critical concentration. These substances were assumed to persist less


Constituent K
Evaluate Q_k
If P_k > 24 hr.
Yes
No
If Solubility > Critical Concentration
Yes
No
Reject
No
If P_k depends on reactivity
Yes
Insoluble listing ranked by Q
List Reaction Product
Soluble listing ranked by Q/Critical Concentration

Q_k = quantity of constituent potentially spilled into water

P_k = persistence time of spill (P_k · 24 hr if K has low boiling point, low solubility and S_p G · 1)

FIGURE 2. **Hazardous Materials Priority Ranking System Flow Diagram**

than 24 hours in the aquatic environment. Therefore, water quality protection measures other than notification of the proper authorities is not warranted. The second decision step divided insoluble compounds of higher boiling points into two categories representative of densities less than one and greater than one. Materials in each of these categories were ranked separately on the basis of Q.

To facilitate data handling, this system was computerized. Appendix A contains the output of the final program run. Ranking by production figures QI and the master ranking Q/cc are presented. The program output includes data on the physical constants, transportation mode, critical concentration, detection methods, detection limits, literature references, and response procedures related to each material. The program presently contains much more information than is utilized by this scheme.

Approximately 250 materials and groups of compounds are ranked in the system. Lack of available production and sales data limited the number of materials which could be ranked. This ranking system will readily lend itself to increasing sophistication as more and better data become available.

Water Use Classification System

While the priority system reflects the potential frequency and severity of spills, the emphasis of this classification scheme is to illustrate the capability of present technology to cope with a spill once it has occurred. The three parameters involved are the detectability of the contaminant, the availability of countermeasures, and the critical concentration of the material. The basic determination is whether a material is detectable and/or can be responded to with present technology as indicated in Appendix B, at levels equal to or below the critical concentration. In this particular application, no attempt has been made to interrelate the four water quality classifications. Consequently, the output is a division of materials into the four water quality parameter categories, each of which is subdivided into classes indicating whether detection and countermeasures are available. Such a classification of over 800 compounds is presented in Appendix C.

Ultimately, it may prove advantageous to integrate this system and the priority system into a single comprehensive scheme. The simplest approach would utilize the priority system to rank individual materials within each classification. Modifications of this nature could easily be worked into the present computer program, but are presently restricted to those compounds for which production data are available.

Recommendations

The continuous addition of materials and updating of information utilized by both systems is recommended. The priority system should form the outline of approach for research programs on specific compounds, and the classification system should be employed to group compounds for administrative and regulatory purposes. In some instances, such as the determination of special permit grants, the classification scheme should be integrated into a single grading.

CAUSES AND SOURCES OF HAZARDOUS MATERIALS SPILLS

Brief

To fully understand the problems of acute spillage of hazardous materials and to develop insight into prevention and control of such spills, it is necessary to examine historical spill data, and production and handling trends. This type of information must be comprehensive if it is to be used as a basis for extrapolation and subsequent prediction of spill trends as a guide to prevention activities.

Presently there are two major sources of historical spill data: transportation accident and handling trend data, and yearly Federal Water Quality Administration fish kill summaries. The transportation data is not sufficient by itself in that spills are not solely the result of transportation accidents. To modify the conclusions drawn from accident histories, it is necessary to also consider Federal regulations concerning transportation, container aspects of product transport, and production trends and locations. While these data alone are still not sufficient for accurate definition of priorities in hazardous material considerations, they do provide a necessary background for identifying future trends in hazardous materials spills.

The existing fish kill reports are inadequate by themselves. They relate only to spills resulting in fish kills and hence do not reflect the total water quality impairment problem. They are further limited by their reliance on state reporting procedures that are often less than optimum.

To rectify this situation, a reporting scheme is recommended which concerns itself with the acute spills of all substances, their causes, and subsequent effects. A new administrative structure is recommended to expedite this reporting and to allow for interplay between the reporting agents and personnel responsible for water quality control.

Transportation System Considerations

The most recent information available on transportation and accident trends as related to hazardous materials has been collected by Booz-Allen and Hamilton in their report to the Council on Environmental Quality.(3) Using direct extrapolation and extrapolation modified by production, transport, and handling trend information, total accident and hazardous-material-related accident figures for the period 1970-1980 have been projected. Oil and petroleum products were included as hazardous materials in this study.

Table 1 is a reproduction of Booz-Allen and Hamilton's total shipment projections for the three modes of transport and liquid product pipelines. Statistics denoting the percentage of an individual compound shipped by each mode of transport are available in Appendix A. Appendix D contains total tonnage figures detailing waterborne hazardous materials handled by individual ports in the United States.

After a comprehensive study of accident statistics, Booz-Allen and Hamilton noted several general trends in accidents involving hazardous materials. Accidents involving hazardous substances are increasing in proportion to the increase in total transportation accidents. Rail and waterborne traffic are experiencing greater numbers of accidents per unit traffic than in the past while motor carriers are maintaining a fairly steady value. Hazardous-materials-related accident frequencies have also increased for rail and waterborne traffic, but are declining for motor carriers. Unfortunately there are no compelling reasons to expect these trends to change for the better and there is good reason to believe that increased tanker size and larger package groupings will increase the severity of individual spills in the future.

Figures 3 and 4 show the total accident and hazardous-materials-related accident statistics for the period 1956-1969 together with projections through the year 1980.(3) While motor carrier statistics are expected to remain fairly constant, rail accidents are projected to increase at 6.8% per year and hazardous-material-related rail accidents are expected to increase at a 5.8% annual rate. The increases appear to be a direct result of several factors. Average train speeds have increased from the 1947 figure of 16 mph to 20 mph in 1968. Simultaneously, train sizes and loads have increased. The average train hauled 1,768 tons of freight in 1968 while its counterpart in 1950 was carrying 1,178 tons. During this same period, no material improvement in railroad

TABLE 1. Hazardous Materials Transported by Major Modes (Booz-Allen and Hamilton)(3)

Mode	Estimated Total Quantity Shipped		Percent Increase	Percent of Total Quantity Shipped	
	1967	Projected 1979-80	1967/1979-80	1967	1979-80
	(In millions of tons)				
Motor Carriers	512	800	56.3%	28.7%	29.0%
Railroads	149	195	30.9%	8.4%	7.1%
Liquid Products Pipelines	709	1,290	81.8%	39.7%	46.8%
Water Carrier	414	470	13.5%	23.2%	17.1%
TOTAL	1,784	2,755	54.5%	100.0%	100.0%

Sources: Interstate Commerce Commission, Transport Statistics, Oil Pipe Lines (1967)

U.S. Army Corps of Engineers, Waterborne Commerce of the United States (1967)

Freight Commodity Statistics, Class I and Railroads and Class I Motor Carriers (1966 and 1967)

American Petroleum Institute

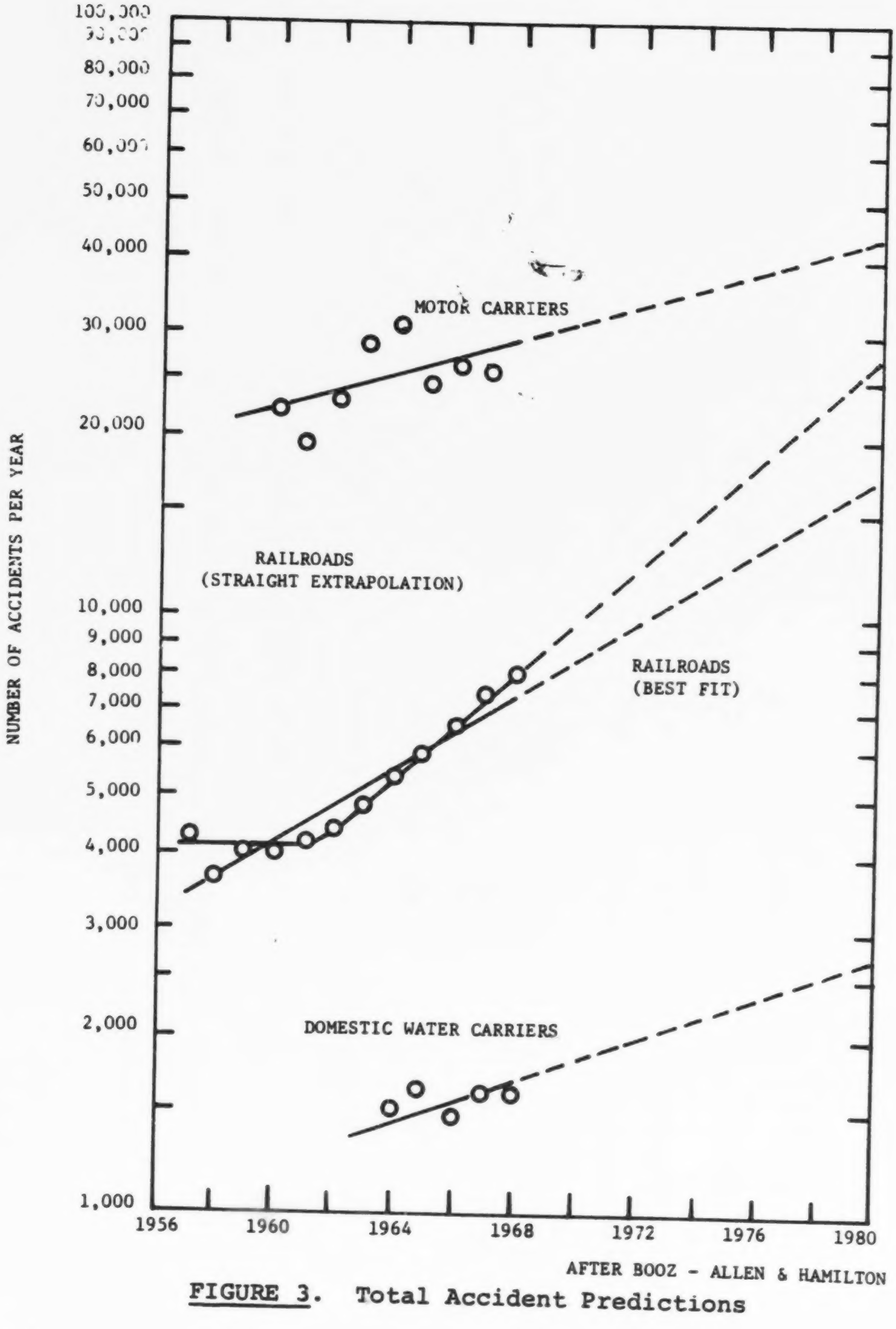
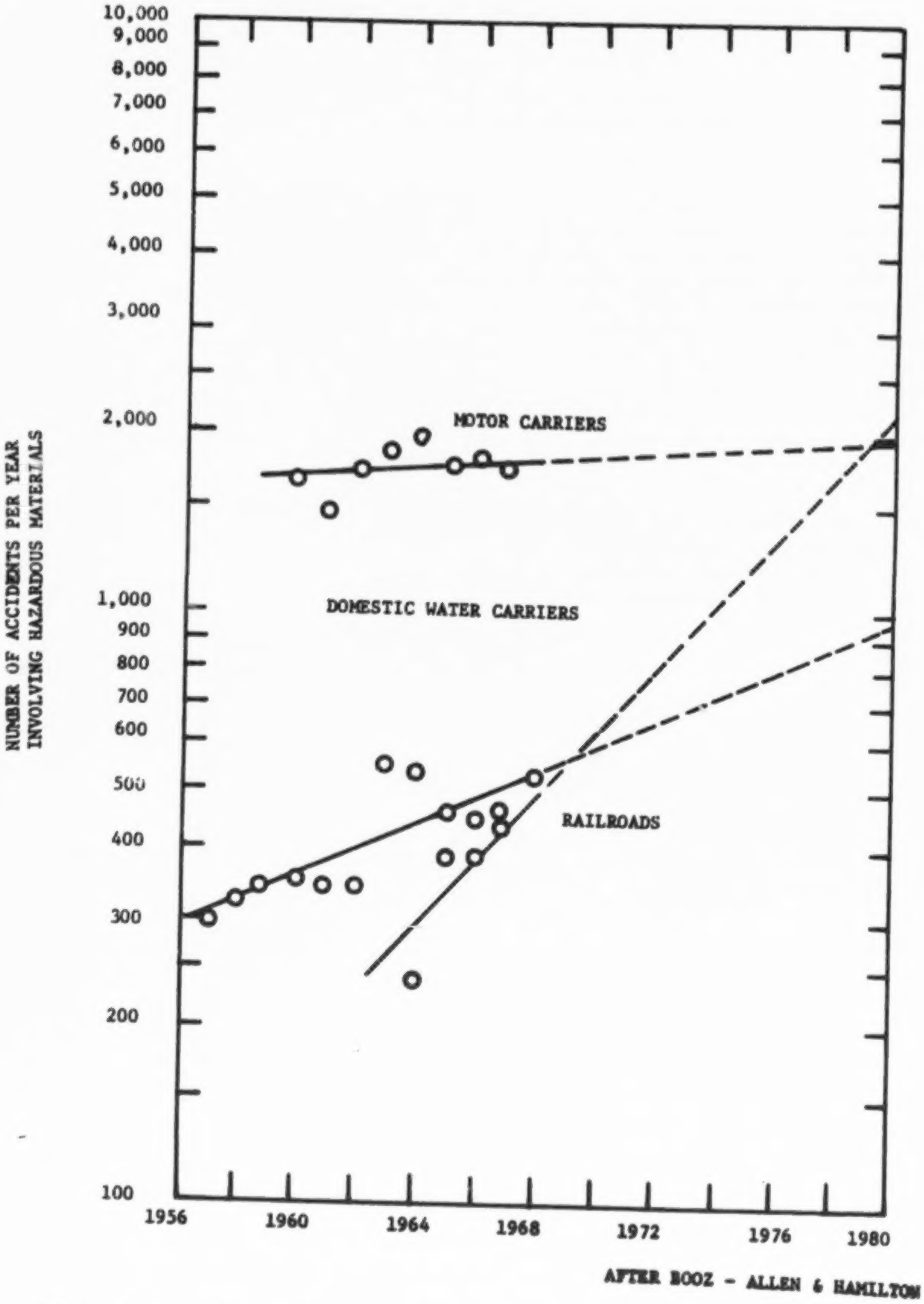


FIGURE 3. Total Accident Predictions



AFTER BOOZ - ALLEN & HAMILTON

FIGURE 4. Hazardous Materials Accidents Predictions

maintenance practices has been realized, partially because of the deteriorating economic situation in the railroad industry. The net effect of these three factors is expected to be an increase in all rail accidents and consequently an increased number of accidents in which hazardous materials are involved.

Total accidents involving waterborne traffic are expected to rise 4% per year through 1980 while hazardous-material-related accidents are projected to increase at an annual rate of 14% over the same period. The difference in these figures reflects the estimated increased percentage of hazardous cargo shipments expected for barge traffic in the 1970's. Meanwhile, overall growth of waterborne traffic should be modest because of a decline in Great Lakes shipping due to increased usage of pipelines. It should be kept in mind that these figures include oil and petroleum products as well as hazardous chemicals.

There has been some discussion as to the appropriateness of the use of production and handling trend information for modifying direct extrapolations of accident probabilities. Such concern, though important, does not bear directly on the present work. The figures used for priority ranking were historical figures unmodified by extrapolation. The predictions for future accidents are presented here merely to indicate trends.

Federal Regulations

Specifications pertaining to the regulation of transport of hazardous substances, whether published by state agencies, transportation industry associations, or others, are largely based on the Code of Federal Regulations Title 49-Transportation.(21) Codification of these regulations is delegated to the Hazardous Materials Regulation Board established by the Department of Transportation. Membership consists of the Assistant Secretary for Research and Technology-Department of Transportation, the Commandant of the U.S. Coast Guard, the Director of the Federal Aviation Administration, the Federal Highway Administrator, and the Director of the Federal Railway Administration or their designees. The Board initiates ruling action upon request of any of its members. Recommendations and requests from other U.S. Government agencies or private individuals and organizations are also considered.

Changes in the regulations concerning shipping by air, rail, highway, and water can be accomplished by the Board utilizing the services and opinions offered by carrier and shipper associations, including the Bureau of Explosives of the Associations of American Railroads. Specifications for shipping containers, methods of packing for shipment, and other regulations are considered and prescribed as conditions appear to warrant. Approved changes require a 90-day notice unless compelling circumstances demand a shorter waiting period. Private concerns may participate in this formulation process by submitting written information or views. The Board also accepts petitions to issue, amend, or repeal a rule. Such petitions may also result from posting of proposed changes in the Federal Register prior to the final decision.

Regulations established by the Hazardous Materials Regulation Board apply to preparation of explosives and other dangerous commodities for transportation by common carriers utilizing rail freight, rail express, rail baggage, highway, or water; construction of containers and packaging; weight; marking and labeling of shipments when required; billing; certificates of compliance with regulations; and loading, storage, billing, placarding, and movement thereof by carriers.

The regulation section dealing with requirements for shippers contains detailed specifications and codes for tank car retest intervals and pressures, maintenance, and refitting requirements. Qualifications are outlined for the use of cylinders and their repair. A listing of explosives and other dangerous materials is supplied and materials are classed as poisons, flammables, corrosives or explosives. Regulations call for placarding and shipping labels referring to the specific class of compound being shipped as a warning to handlers and as a quick reference source in case of an accident. The listing also includes packaging requirements and exemptions, label requirements, and maximum allowable shipment quantities.

The extremely complex nature of transporting hazardous materials has led to the institution of a system of special permits which waive or exempt individual situations from Parts 171-190 of Title 49, Chapter 1 or Part 103 of Title 14 of the Code of Federal Regulations.(21)

Having decided that a shipment cannot be made under present regulations, a shipper must petition the Board for a special permit. Over 3,000 special permits are currently outstanding. The petition itself must contain information describing the regulation provisions involved, a justification for the permit, detailed descriptions of the proposed plans and containers, chemical background information, relevant shipping and accident experience with the proposed container, proposed transport mode and any special transportation controls required, the name of the petitioner, and a statement or recommendation regarding any changes in the regulations which would be desirable to eliminate the need for similar special permits. From this information and any additional facts that are available, the Board rules on each petition. The special permit process and the regulation formulation process do not specifically include consideration of effects on water quality.

Packaging and Containerization

Changes in chemical production in recent years, advancing technology and more diverse markets have made the selection of the shipping mode an increasingly complex function. Among the factors involved in determing the mode of transport are safety considerations; product characteristics and unit value; size of shipment; distance to highways, waterways, and/or a variety of possible modes of shipment including: small containers, bulk railroad transport, tank truck, barge shipment, intermodal transport, and containerization. Both dedicated service and multiple product systems are employed.

Small Containers: Liquid shipping containers range from small glass vials to 40-foot containerized tanks. The 55-gallon steel drum, however, is the liquid-carrying work horse of the chemical industry and its use has expanded rapidly with the advent of corrosion resistant linings. A variety of linings combined with different burst strengths, thicknesses, openings, sizes and manufacturing techniques has been responsible for the versatility and universal acceptance of steel drums. Drums are usually filled by gravity, by pump, or pneumatically under a variety of conditions depending on product characteristics such as volatility, flammability and reactivity.

Aside from in-transit punctures or container failure due to corrosion, product expansion, or rough handling, the greatest potential for spill or leakage occurs during filling and unloading operations.

Reconditioning of drums can also present a spill hazard. Specifications cover three drum classes: reusable, single trip, and nonreturnable. Only drums in the first two classes may be reconditioned. A rinse or wash is often sufficient for reconditioning; however, use for some compounds requires a more thorough cleaning and overhaul. The reconditioning process is potentially a spill source depending on the reconditioning methods and facilities. The ultimate disposal of drums presents a threat to the public health and welfare because of secondary environmental exposure from abandonment or typical uses such as pesticide drums as floats for marinas.

Nonmetal containers are being increasingly utilized for liquid shipments up to 55 gallons. These units can accommodate weights up to about 600 pounds and can be used to carry a variety of materials. For example, polyethylene and polypropylene containers can be used for acids, bases, halides, and organics. Fiber drums and corrogated boxes can be fitted with plastic linings to increase package integrity under accident conditions. However, these types of containers are more susceptible to puncture during transport. Present trends result in an increase in composite materials and new combinations of products fabricated from plastic and paperboard materials. This offers a good compromise between economics and container durability.

The majority of plastic containers are nonreturnable and nonreusable. Therefore, due to the nature of the material, loading and unloading operations present the major potential for spills with these containers. This type of risk can be minimized by proper regulation and enforcement and by adequate control facilities at the filling and use sites.

Bulk Railroad Transport: Most chemical industry products must be shipped in greater volume than that which can be carried economically in small containers. Railroad tank cars move the largest volume of bulk liquids, and the Department of Transportation has classified approximately 75 types of cars for carrying over 1,000 different commodities. Some common classifications are given in Table 2.

Cars are designed to cope with liquid properties such as corrosiveness, toxicity and vapor pressure. A high-pressure tank car is one with a safety valve setting of 75 psi or more. These are required for flammable or toxic liquids whose vapor pressure exceeds 27 psia at 100 °F. Cars classed as low pressure vehicles have safety valves set at less than 75 psi. Safety vents with rupture discs can be used in place of valves.

General service cars for low pressure and nonregulated commodities comprise the vast majority of cars in use. Even so, designs include multisectioned units with broad pressure and temperature control capabilities. Loading is normally done through the car dome, and unloading

TABLE 2. Common Tank Car Classifications (2)

Classification	Type	Typical Commodities
AAR	Nonpressure steel	Brine, ethyl benzene, glycols, heavy fuel oils, liquid latex, vegetable oils.
ARA	Nonpressure steel	Brine, ethyl benzene, heavy fuel oils, molasses, vegetable oils.
00T 103W	Nonpressure aluminum	Acetone, amines, aqua ammonia, caustic soda solutions, chlorinated solvents, ethyl benzene, ethylene dibromide, fats and oil, gasoline, glycols, latexes, liquid fertilizer, petroleum products, phenol, ployglycols, weed killers.
00t 103A1W	Nonpressure aluminum	Acetic acid, amines, formaldehyde, glycerine, glycols.
00T 111A60ALW	Pressure steel	Anhydrous ammonia, anti-knock compounds, bromine, butane, ethylychloride, ethylene oxide, liquid chlorine, methyl chloride, propane, propylene, propylene oxide, vinyl chloride.

through a bottom outlet. For safety reasons, acid and other material cars, like ethylene oxide, are loaded and unloaded via the dome fittings.

Derailment presents the major potential for railroad spills. Findings of the investigation following the Dunreith, Indiana incident, indicate that a broken rail at a compromise joint connecting two different sized rails was responsible for the derailment. Their study also indicates that such circumstances are fairly common.(54) The frequency of local inspection is such that this type of irregularity often remains undetected. Out-of-level roadbeds can cause problems as in the case of the Laurel, Mississippi incident,(74) where a track crossing provided the necessary jolt to shatter a tread-worn-hollow wheel, derailing the train and releasing chlorine. Conclusions drawn in the investigations of both accidents point out the need for better inspection of roadbeds and equipment. Such recommendations have instigated moves to require increased attention to wheel and axle testing on all rail cars.

Potential tank car leaks and spills stem not only from derailments and vessel failures caused by unforeseen circumstances, but by leaks and spills at loading and unloading terminals, and equipment and valve failures.

Bulk Tank Truck Trailers: The key role of tank truck trailers is to provide a broad range of services and door-to-door operation from shipper to customer. For local deliveries, one tank can make several trips per day with loads ranging from 2,600 to 8,500 gallons.

One of the competitive advantages of the trucking industry is that the carrier unloads cargo as opposed to the customer as in other transport modes. Trucks are best suited for the medium and high value commodities usually shipped in smaller quantities. Economic factors influencing the use of this mode include the expense of long hauls with deadhead return and comparatively restricted load capacity. Truckers are currently offering more versatile trailer service that allows them to reduce deadhead return trips.

Similar to tank cars, tank trailers offer a wide flexibility in terms of construction materials, sizes, insulation and auxiliary support systems. Because of their similarities to tank cars, they possess similar spill and leak potentials magnified by the fact that they operate under less isolated conditions than railroads.

Bulk Barge Shipment: U.S. inland and coastal waterways offer a comparatively inexpensive shipping method. Barges capable of holding up to 2,500 tons can be pushed or towed in groups containing up to 40 individual units. Anhydrous ammonia barges have capacities up to 3,000 tons.

Approximately 2,600 tank barges are currently in service in the United States. Maximum value of waterway shipments is obtained when the shipper has direct access to terminals at both ends and some control over handling charges. Thus, many producing companies have found it advantageous to operate their own barges. About 25% of the 17,000 barges in this country belong to private shippers.

Barges, of course, can be no wider than the locks they use. Also, uniform dimensions are desirable for two operations.

Standard barge sizes are: widths, 35 and 52.5 ft; lengths, 195 and 250 ft; and drafts, 9 to 14 ft, depending on the waters being navigated. Rafting of barges to form 1,200-foot tows is not uncommon.

Barges are not necessarily limited to inland waterways. Units designed for ocean travel and holding 8,000 to 20,000 tons follow routes between mainland ports and Puerto Rico, Alaska and Hawaii.

Tank barges are of three general types:

- Single skin, where cargo is carried directly within the outer shell of the vessel. These barges are ordinarily used where no special precautions are deemed necessary for the cargo.
- Double skin, where cargo is carried within an inner shell. The additional shell prevents contamination of the water or cargo should a leak occur and also provides a smooth tank interior for special coatings and ease of cleaning. These barges may be compartmented.
- Independent tank, where cargoes are carried in separate tanks mounted on saddles in the hull. Cylindrical tanks are common where cargoes must be transported under pressure and/or high or low temperatures. These separate tanks are easier to insulate heavily for shipments requiring either elevated or depressed temperature.

More liquid products move by barge than any other type of commodity. While petroleum products still account for the largest share of these movements, the amounts of liquid chemicals being transported by barge has been steadily rising.

There has also been a trend toward larger tows. Whereas 5,000 tons was once the usual tow, there is now an increasing number near the 10,000 range, and 15,000 ton tows are not out of the ordinary.

In addition to the obvious sources of collision and sinking, spills from barge traffic can occur from two types of operation: loading and unloading, and bilge disposal. Non-corrosion resistant loading and unloading equipment often leads to product leakage into watercourses. Many terminal facilities do not provide adequate piping for dedicated loading and unloading of special commodities. Consequently, products become mixed, increasing the probability of binary reaction and possible subsequent explosion or fire.

Frequently to circumvent these latter problems, lines are drained into the watercourse or into the bilge. In either case, the material is introduced into the water since bilges are often pumped while underway.

All of the above factors are aggravated by the lack of technical knowledge on the part of on-board personnel. Most handlers and shippers have inadequate appreciation of the properties of the products they are handling. Use of brand name items further confuses the situation.

Another contributing factor is the lack of licensing requirements for tugboat operators towing barges.

Manufacture and Use of Hazardous Materials

Stationary Spill Sources

In general, hazardous materials studies tend to focus on transportation accidents as the major source of acute spills, thus drawing attention away from spills originating from storage or production facilities. Upon examination of historical data, however, it becomes apparent that stationary sources represent a significant portion of the total problem. Numerous fish kills result from leaks from storage tanks and broken lagoon dikes.

Bulk fluid storage can be achieved in three ways: atmospheric pressure storage, low pressure storage, and pressure storage. Atmospheric pressure storage includes use of open reservoirs, lagoons, and any closed vessel designed for a maximum pressure of 0.5 psig. Low pressure vessels are closed tanks rated between 0.5 and 15 psig, while pressure vessels include all tanks designed for pressures above 15 psig.

Storage facility spill problems vary with the equipment being used and the fluid being stored. Lagoons and reservoirs are normally bounded with earthen dikes or reinforced earthen structures. They are constantly threatened by weathering or rodent infestation which can weaken the structure to the point of collapse. The occurrence of percolation in waste lagoons causes a further problem. Many times lagoons saturate the ground with toxic substances which remain long after use of the lagoon has ceased. Strong flushing action can then drive the toxic material out to nearby surface waters. Such a case occurred in Meadville, Pennsylvania, when discharge of a large volume of water flushed acetic acid and diketene wastes from an old lagoon site.(53)

Metal cylindrical tanks used as pressure vessels are subject to different types of stresses. Corrosion, lightning, leaking gaskets, mechanical puncture, static electricity, faulty pressure relief equipment, and inadequate insulation can all result in failure. When outdoor tanks are employed, they are often grouped in tank farms for economic reasons. This multiplies the hazard in the event of fire, explosion or natural disaster. Large storage areas of this nature are common to production sites and transportation terminal locations. This is especially true for areas handling large volumes of waterborne traffic. Hence, port facilities, crude oil depots, and refineries demand a great number of liquid storage vessels.

Smaller storage operations are located across the entire country. Vessels are required to store ammonia for fertilizer operations, chlorine for water and wastewater disinfection, natural gas for fuels, acid for stripping plants, and caustic for food blanching and pulping. These are frequently small operations, which may or may not follow safe handling procedures. Small private facilities such as might be maintained by a farmer to store ammonia solutions often do not undergo routine inspection.

Causes of spills which are common to all storage facilities include human error, transfer equipment malfunction, and natural disasters.

To minimize loss from stationary storage facilities, generalized safety requirements have been established. These include the more obvious selection requirements to insure the vessel material is compatible with the fluids to be stored and that it can withstand expected pressures or vacuum. Venting requirements are based on pumping rates, ambient temperatures expected, and vapor pressures.

Fluid tanks constructed for use with flammable liquids must be grounded and should be placed so that fire extinguishing equipment is readily accessible. Perimeter dikes of minimum sufficient capacity to contain the volume of the enclosed tanks are often required.

In general, dry storage facilities do not pose any immediate threats to the water environment. The relatively immobile state of the material, the ease of recovery of spilled material, and the tendency to individually pack smaller size units diminish the chances of the contaminant reaching water once it has been released. Accidents result from explosions and fires common to "high dust" operations. Specific plans to move stored hazardous, dry materials from sites subject to flooding will generally be effective because of the lead time normally available prior to a major flood.

Production Statistics

Recent slumps in the economy have affected production in the chemical industry. With current indicators pointing to a more solid economy in the future, projections are for the earlier trends of rapid production increase to resume. Following this air of optimism, chemical producers are planning ambitious construction programs for the 1970's.

Tables presented in Chemical and Engineering News(45) show the historical development of production and are given in Appendix D.

Geographical Factors

Production quantities alone cannot be used as indicators of quantities of materials potentially introduced into the aquatic environment. As developed below, other factors require consideration. These factors are not amenable to a numerical formulation to establish which materials deserve priority attention.

One method of approach toward presentation of geographical factors is to map out production sites and market regions for individual materials together with production trends, cost trends, and use patterns. This has been done in Figures D-1 through D-10 of Appendix D for ten of the top priority ranked materials (as developed in Appendix A of this study).

The value of such maps can be illustrated by consideration of phenol. Phenol was ranked first by the numerical formulation and thus should pose the greatest threat to the aquatic environment. However, Figure D-9, Appendix D indicates that 50% of present phenol production is captive. That is, 50% of manufacturing operations produce phenol for in-plant use. The actual amount of phenol in transit is well below the production quantity. Thus, an accidental release of phenol will depend to a great extent upon handling procedures in and around manufacturing facilities as well as on transport.

Conversely, Figure D-3, Appendix D shows that chlorine production is located on the West Coast and east of the

Mississippi with markets nationwide. This indicates that large quantities of chlorine will be in the transportation system, hence transport mode accident probabilities are a major factor in determining spill potential.

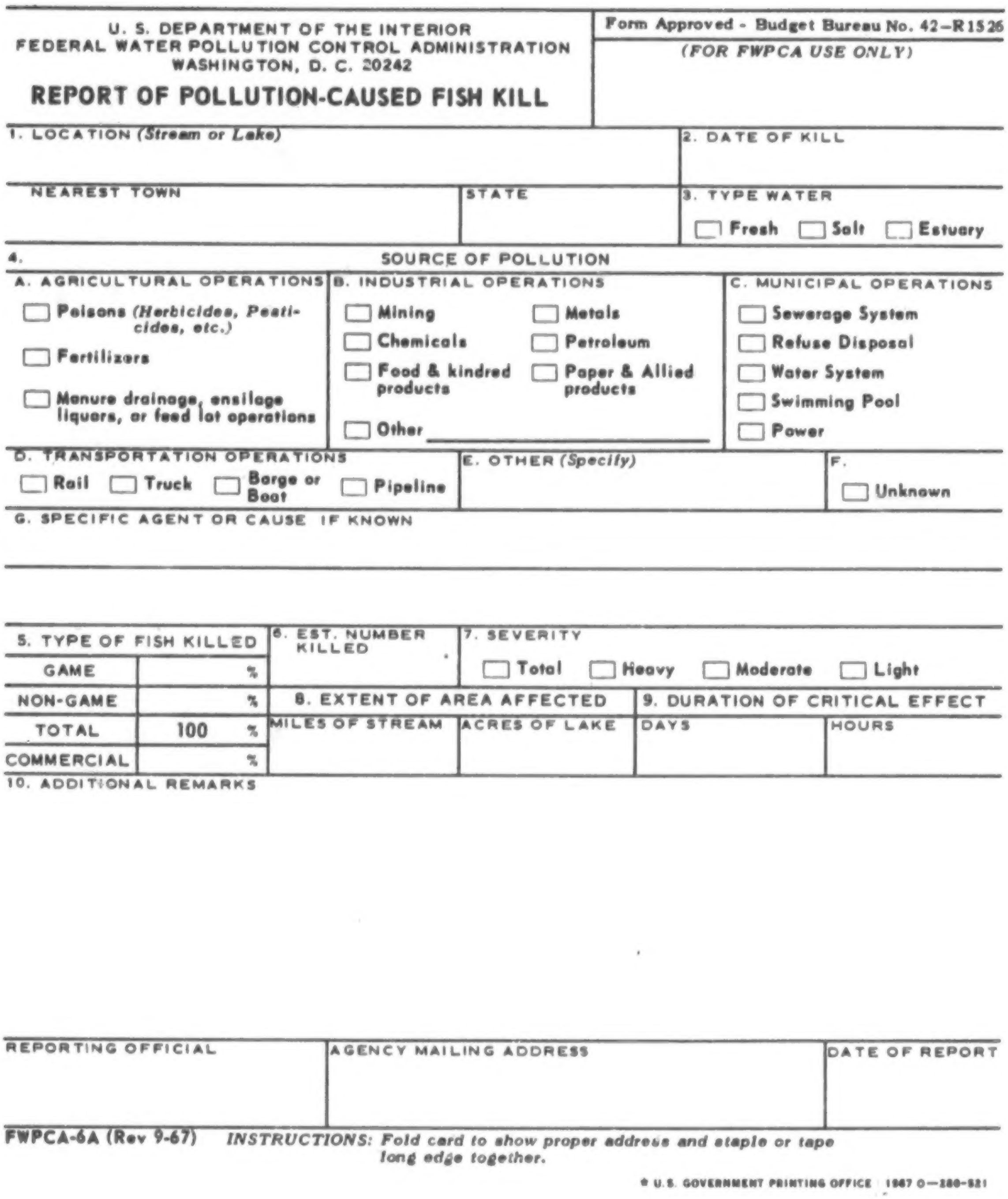
Historical Spill Experience

National Summaries

Since the present level of concern with the impact on water quality resulting from spills of hazardous substances is relatively recent, only a limited backlog of information on past spill incidents exists. Historically, nationwide data on spill incidents has been compiled principally on the basis of fish kill observations that have been tabulated annually by the Federal Water Quality Administration. This program, initiated in 1960, dpends upon voluntary reports submitted by individual states. The report form presently being used is illustrated in Figure 5. This report form requests certain data, such as the source of the pollution incident, which are desirable but often difficult for the volunteer to accurately determine.

As a result of the reliance on voluntary reports, yearly data summaries often reflect the thoroughness of the reporting procedures of the individual state, rather than the actual geographical density of spills. Frequently, for lack of data these reports do not contain information as to the exact contaminant spilled, the quantity, and the type of container involved. This makes the tasks of evaluating container integrity and correlating spill severity to spill size, almost impossible. Some individual states have begun to collect more detailed information for their own use. Among the concerns of states not presently reporting all incidents is the question of liability once the spilled compound has been identified and its sources revealed. Frequently, their position is that unless the source can be positively identified, the incident should not be reported at all. Clarification of this point could considerably expand the available data base. The question of liability will be discussed in the section on the legal aspects of hazardous materials. Reports are generally filed by fish and game officials or local wardens. In some states this coverage may be inadequate.

Regardless of the preceding circumstances, Federal Water Quality Administration annual fish kill summaries represent the best available data source. The fact that in situ or "natural" bioassay data, i.e. the fish kills, represent the



U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
WASHINGTON, D. C. 20242

REPORT OF POLLUTION-CAUSED FISH KILL

Form Approved - Budget Bureau No. 42–R1526
(FOR FWPCA USE ONLY)

1. LOCATION *(Stream or Lake)*
2. DATE OF KILL

NEAREST TOWN
STATE

3. TYPE WATER
☐ Fresh ☐ Salt ☐ Estuary

4. SOURCE OF POLLUTION

A. AGRICULTURAL OPERATIONS
☐ Poisons *(Herbicides, Pesticides, etc.)*
☐ Fertilizers
☐ Manure drainage, ensilage liquors, or feed lot operations

B. INDUSTRIAL OPERATIONS
☐ Mining ☐ Metals
☐ Chemicals ☐ Petroleum
☐ Food & kindred products ☐ Paper & Allied products
☐ Other ____________

C. MUNICIPAL OPERATIONS
☐ Sewerage System
☐ Refuse Disposal
☐ Water System
☐ Swimming Pool
☐ Power

D. TRANSPORTATION OPERATIONS
☐ Rail ☐ Truck ☐ Barge or Boat ☐ Pipeline

E. OTHER *(Specify)*

F. ☐ Unknown

G. SPECIFIC AGENT OR CAUSE IF KNOWN

5. TYPE OF FISH KILLED		
GAME		%
NON-GAME		%
TOTAL	100	%
COMMERCIAL		%

6. EST. NUMBER KILLED

7. SEVERITY
☐ Total ☐ Heavy ☐ Moderate ☐ Light

8. EXTENT OF AREA AFFECTED		9. DURATION OF CRITICAL EFFECT	
MILES OF STREAM	ACRES OF LAKE	DAYS	HOURS

10. ADDITIONAL REMARKS

REPORTING OFFICIAL	AGENCY MAILING ADDRESS	DATE OF REPORT

FWPCA-6A (Rev 9-67) *INSTRUCTIONS: Fold card to show proper address and staple or tape long edge together.*

☆ U.S. GOVERNMENT PRINTING OFFICE 1967 O—280-521

FIGURE 5. The Form Presently Employed for Reporting Fish Kills to the Federal Water Quality Administration

major national indicators of water quality degradation resulting from spills is significant in that only one of the beneficial uses of water is covered.

Geographical plots of spill incidences reported in the annual Federal Water Quality Administration fish kill reports from 1960 to 1968(30,60,69,76) are contained in Figures D-11 through D-14, Appendix D. This Appendix also includes tables summarizing fish kill information for the same period.

Many observations can be made from comparative analyses of this historical data; but, in most cases, the data are representative of only a portion of the total reports since information on the duration of spills, total fish killed, or percentage of fish population affected are not reported. Many reports also state that the kill was of unknown origin. This suggests that if conclusions are to be drawn from these tables, they should be done so carefully and with the full knowledge of the incomplete nature of the data. Considering all factors the statistical significance is doubtful and meaningful trends cannot be established.

Appendix D also includes detailed analysis of spills in California and Illinois. These help to illustrate that spill locations may reflect transport or use patterns of hazardous materials.

Past Major Incidents

Despite a rather extensive effort during the course of this study, only a small amount of well-documented information relating to water pollution aspects of past incidents was uncovered. This appears to be due to a number of factors including: 1) most incidents are on a small scale and the effects are of short duration; 2) most incidents have resulted in problems in which water quality aspects attract less attention than fire, explosion, or air pollution threats; 3) a routine reporting and follow-up system is not in place particularly as regards the more technical aspects; and 4) the agencies involved are sometimes reluctant to make such reports generally available, although documentation of incidents may exist.

Two recent incidents which have been well-documented and openly reported occurred at Dunreith, Indiana and Carbo, Virginia. These incidents are described and analyzed below.

Dunreith, Indiana:(54) At 9:30 PM on January 1, 1968, a train wreck involving approximately 30 cars occurred at the small town of Dunreith, Indiana, which is located on Buck Creek, a tributary of the Big Blue River. Five 20,000 gallon tank cars carried hazardous materials: two contained acetone cyanohydrin, one vinyl chloride, another ethylene oxide, and the last methyl methacrylate. The Indiana State Patrol immediately contacted the State Health Commissioner who dispatched a representative to the scene within a few hours.

Fire, explosions, and the release of toxic gases prompted the evacuation of the townspeople and a technical evaluation of the chemicals involved. Acetone cyanohydrin is a soluble, stable liquid that decomposes to acetone and hydrogen cyanide, a highly toxic chemical. Vinyl chloride is a low boiling, slightly soluble gas that can be narcotic at high concentrations. Ethylene oxide is an insoluble, low boiling liquid; an irritant at low concentrations,it can be fatal at higher concentrations. Methyl methacrylate is a low density, slightly soluble liquid which boils at 100°C.

Because of the hazards involved with extinguishing the fire, it was decided to let the fire burn itself out and wait for representatives from Dow Chemical Company and Rohm and Haas Chemical Company to reach the scene. Meanwhile, residents were not allowed to return to the town and workers were required to wear gas masks.

The first indication of water quality damage resulting from the spill was noted at noon the following day when motorists sighted several dead cattle and dead fish along the banks of Buck Creek. An ensuing investigation revealed seven dead cattle, several dead hogs, and thousands of dead fish. The characteristic odor of cyanide was prevalent in the stream water. Additional personnel arrived and obtained samples for analysis at the State Board of Health Water and Waste Laboratory. Samples taken through the morning of January 3, contained maximum cyanide concentrations of 405 mg/liter in Buck Creek and 20 mg/liter in the Big Blue River.

After the fire was extinguished on the afternoon of January 2, it was determined that the ethylene oxide had exploded while the methyl methacrylate and vaporized vinyl chloride burned. Only acetone cyanohydrin from one of the cars reached the surface water. About 1,200 gallons seeped into the roadbed and ran down a tile drain to the creek.

State and industrial personnel supervised the decontamination of the roadbed materials. Meanwhile, owners of nearby private wells were advised to avoid use of well water while a sampling program was initiated.

Further sampling downstream confirmed the belief that even though dilution and decomposition were acting to lower the effective cyanide concentration, recommended standards would not be met before the slug reached Seymour, Indiana, which utilized the water for its domestic supply. To avoid shut down of Seymour's water, it was decided to convert the cyanide to cyanate with chemical treatment. On January 5 and 6, 6,200 pounds of calcium hypochlorite were added gradually to the stream at a cost of $3,083, which was borne by the railroad. This hypochlorite treatment was adequate to reduce the cyanide below the 0.20 mg/liter recommended limit. Dead fish were noticeable in decreasing numbers below the treatment site and may well have resulted from the free chlorine as well as the remaining cyanide.

Monitoring was continued and boxes of live minnows were set in the stream to detect any remaining toxicity. An extensive program was then initiated at the railroad's expense to test the surrounding ground water. When contaminated water was detected, it was pumped out, treated, lagooned, and bled off to the receiving stream. This program continued well into April, when snow melt leached additional cyanide into the ground water supply

In a summary report, Indiana State Health officials concluded that hazardous chemical transport poses a growing threat to the safety of all individuals. Moreover, they felt that the successful treatment of the cyanide showed the type of rewards that could be realized if a comprehensive handbook for combating chemical agents was available. It was also concluded that the response showed how personnel of different agencies could cooperate efficiently to minimize the dangers of such a spill. All three observations, while valid, do not complete the picture. Several lessons can be learned from the Dunreith incident.

While the response team appears to have been both efficient and effective, valuable time was lost waiting for the flammable materials to burn out and for industrial representatives to arrive. The rationale behind this was to avoid confronting some of the more dangerous hazards before conferring with experts on the chemicals involved. The information sought from the Dow and Rohm and Haas people should be available to public officials in the form of a hazards manual or information system. If such were the case, response personnel could immediately begin countermeasures and perhaps contain or counteract much of the leakage of chemicals.

While a primary concern must necessarily be fire, explosion, and toxic gases, it is evident that more concern must be directed toward water quality. Although consideration was given to domestic supplies both from private wells and the Seymour water system, this concern was late and incomplete. The existence of nearby wells or river intakes could have led to serious consequences for unwary users long before the January 2 observations led to analysis of the stream water. While local well owners were warned, a complete understanding of water uses and users in the vicinity and downstream could have been invaluable for early warning.

In the Dunreith disaster, major concern was directed toward personal and property safety. Meanwhile thousands of fish and some livestock died. These losses may well have been reduced if a water quality specialist had been on hand. Chlorine treatment within hours of the spill could possibly have saved thousands of fish and prompt notification of local farmers could have prevented the loss of livestock.

Clinch River Fish Kill:(20) On Saturday, June 10, 1967 at 10:30 AM, a dike containing an alkaline waste lagoon for the Appalachian Power Company steam plant at Carbo, Virginia collapsed and released approximately 400 acre-feet of fly ash waste into the Clinch River. The resulting contaminant slug moved at a rate of one mile per hour for several days until it reached Norris Lake in Tennessee; whereupon, it is estimated to have killed 216,200 fish. All food organisms in the four-mile stretch of river immediately below Carbo were completely eliminated.

The regional Director of the Middle Atlantic Region of the Federal Water Pollution Control Administration was notified of the dike failure on Monday, June 12. At this time, action was taken to establish the extent and location of the pollutant. Contact was made with the Virginia Water Control Board and the Tennessee Stream Pollution Control Authorities to determine the number of public water supplies threatened and the availability of alternate water sources. Only Saint Paul, Virginia directly used Clinch River water in the potentially contaminated reach, and it had obtained its weekend supply before the polluted water arrived.

Officials worked with the Tennessee Valley Authority to monitor the incident. Lines of communication and reporting procedures were established to keep the Regional Director assessed of the movement of the material. Initially, observation could be made by the milk-white $CaCO_3$

and $Mg(OH)_2$ precipitates. Ultimately, pH and alkalinity were used as the basic indicators for observing the movement. On June 13, the FWPCA Regional Office supplied an engineer to assist in the monitoring. The agencies involved with data collection included the Middle Atlantic Regional Office of the Federal Water Pollution Control Administration, the Tennessee Game and Fish Commission, the Fish and Wildlife Service of the U.S. Department of the Interior, the Virginia Water Control Board, and the Virginia Game Commission. Results showed that the precipitation of magnesium and calcium occurred for the first 35 miles, at which time the contaminated plume was 18 to 20 miles long. The high pH, low alkalinity slug then passed on downstream until it reached Norris Lake.

Methods for controlling the pH and thus neutralizing the spill were considered. It was estimated that approximately ten 50-ton tank cars of sulfuric acid would have to be dumped within a 30-minute time period. Since such a supply was not available and there was concern for further precipitation of alkaline salts, this course of action was not taken.

On June 15, one of several follow-up meetings was held to discuss the circumstances concerning the spill. The Appalachian Power Company agreed to pay for damages. Several possible causes of the dike failure were discussed and appropriate corrective actions outlined to insure against a recurrence. Fly ash handling policies in general were also reviewed.

While liability assessment and preventive developments to reduce further occurrences were adequate, the physical response to the Carbo spill was less than optimum. The reporting of the incident was far too slow to meet the dangerous situation that could have developed. If the town of Saint Paul had been drawing water at the time the contaminate was flowing by, serious consequences could have resulted. The lack of early reporting and/or warning increased the potential hazard of the situation. It was fortunate that the intakes were shut down before the contaminant passed.

The second major gap in the response was the lack of any countermeasures. Application of even inadequate quantities of acid for neutralization would have reduced damages to some extent. Although no value was immediately placed on the fish involved, it should not require a purely economic balance to warrant the use of countermeasures to effect early restoration of a stream. If a water quality specialist could have been on hand to assess the needs and order the required countermeasure (acid neutralization) on Saturday the 10th, shortly after a release, the spill could have been at least partially treated prior to its enlargement to 20 miles in length at Clinchport, Virginia.

Recommendations

Recommended Reporting Procedure

To resolve the problems involved with the present systems utilized for tabulation of historical data, a new reporting system and administrative structure is needed. Reporting should be extended to cover water quality effects other than fish kills. Initial reports of spills will emanate from a variety of groups and individuals not necessarily concerned with the water quality aspects. State patrols, Coast Guard, and rail inspectors should report incidents resulting from transport accidents. Local game wardens should report unusual fish kills or wildlife deaths, while water treatment plant operators should report unusual changes in influent and effluent qualities including aesthetic features. Handlers of hazardous materials should further receive positive motivation for reporting spills.

All reports should be funneled promptly through a regional water quality agent. This will allow for rapid follow up to determine all desired information. In addition to information presently supplied, reports also should include information on the container involved, the nature and quantity of substance spilled, and response measures taken plus their effectiveness.

The regional agent, when satisfied with the local input, would then translate the information into a form appropriate for transmittal to a historical data accumulation bank. Periodically, the data bank could be utilized to determine such things as container failure history and effectiveness of countermeasures.

It is suggested that such a reporting system be implemented and subsequently that it be extensively utilized for providing historical backup and predictive guidelines for regulatory changes and research efforts in hazardous materials handling.

Additional Recommendations

- It is recommended that, since accident frequencies involving hazardous materials are increasing in the rail and waterborne transportation modes, consideration be given to limiting the quantity of highly hazardous polluting substances that can be carried in any single vessel.

- It is recommended that, since inadequate railroad maintenance can be a strong contributor of accidents in this mode of transport, the use of the rail transport for certain materials should be regulated depending on roadbed condition. Such regulations might, for example, govern speeds or maintenance standards on tank cars carrying hazardous materials.

- It is recommended that, since definitive statistics on waterborne traffic in hazardous substances are lacking, the annual summaries prepared by the Corps of Engineers be amplified in detail for high concern materials. This would provide regional groups a firmer grasp on the nature of threats and aid in their planning.

- It is recommended that, since dedicated service transport vessels offer a lower potential for spillage due to the less frequent need for cleaning and the reduced likelihood of combining antagonistic materials, industry should continue to increase the use of dedicated service systems and consideration should be given to requiring this use for high concern materials. This recommendation also applies to terminal loading and unloading facilities.

- It is recommended that, for high hazard commodities, consideration be given to requiring double skin construction for barges carring these materials.

- It is recommended that, since waterborne barge accident frequency is increasing, licensing be required for all operators. Those involved in transport of high hazard materials should receive special training in the nature of materials involved.

- It is recommended that, since storage facilities, particularly lagoon systems, can be a major source of spillage or seepage, consideration be given to establishing design standards that must be met prior to the use of lagoon storage.

- It is recommended that, since the use of many hazardous materials involves nontechnical personnel, the producing industry involved should provide these users with technical advice as to equipment inspection and maintenance, and provide instructions for disposal of used containers.

- It is recommended that the classification system developed in this study be considered in the regulation and special permit issuance processes. All standing regulations pertaining to individual substances should be reviewed in light of this classification system and altered if a substance poses a major threat to water quality. It is further suggested that all new products be subjected to classification before bulk quantities are transported.

- It is recommended that the transporter of highly hazardous substances be required to carry specific aids for detection and reduction of water quality damage. These should include communications systems for immediate reporting of any accidents and perhaps a traceable dye to introduce to the water course at the time of the spill. The transport vehicle itself should also be placarded with the specific reporting procedure necessary in the event that the operator is incapacitated. In addition, rail and truck operators carrying high hazard materials should have equipment available to aid in preventing spills from reaching surface waters. This equipment may range from a hand shovel to diking agents such as bentonite clay or foaming agents.

- It is recommended that one agency be identified as solely responsible for water quality inspection and disaster prevention during a spill incident. Parallel to safety efforts, it would warn all possible water users of potential hazards and immediately establish a monitoring system and provide water quality protection knowledge to the response system. These activities are to be accomplished in accordance with the contingency plans as described in other sections of this report.

- It is recommended that, since fish kills represent evidence of only one water quality parameter impairment, the reporting system should be augmented to include water quality impairments other than fish kills. Further, it is recommended that, since despite a diligent search of available literature, very few spill incidents have been found to be well-documented, in major incidents follow-up reporting be provided to evaluate the fate and effects of the pollutant and to assess the adequacy of countermeasures and determine damages.

DETECTION AND MONITORING

Brief

In this report "monitoring" refers to measuring the concentration of a constituent or water quality characteristic either intermittently or continuously over a period of time. "Detection" on the other hand relates to identifying the existence and/or measuring the concentration of a constituent or water quality characteristic at any time during a pollution incident.

There are several distinct needs relating to detection and monitoring of hazardous material spills. Since spills often remain unreported, there is a need for a mechanism for initial detection or discovery of the spill event. Following the discovery of the spill, it is necessary to determine the nature of the contaminant. This may require laboratory analysis. Finally, it is necessary to monitor the spread of the contaminant from a point or line source utilizing field detection methods.

A review of existing continuous monitoring systems to determine hazardous materials spills and available laboratory and field detection techniques indicates that these systems and techniques are generally inadequate. Therefore, it will be necessary to develop new concepts in monitoring and detection of hazardous material spills.

Monitoring facilities should be installed in areas where (1) frequent spills have occurred; (2) a high, important water use occurs; and (3) designated materials may be discharged in excess of quantities which produce more than a negligible risk. Development of complete monitoring facilities for all waterways is deemed too costly and unnecessary for present needs.

It was found that information concerning detection techniques applicable to acute spillage problems and detailed instructions are nowhere combined in a single, accessible source. The need for continual upgrading of such a work has sponsored the recommendation of an automated data bank to store all pertinent information.

Need for Detection Procedures

In the event of spillage of hazardous polluting substances, one of the most immediate needs will be for analytical methods capable of qualitative detection and quantitative determination of spilled material at threshold concentrations for water quality impairment. In many instances, human sensory perception may be adequate but for the majority of materials evaluated in this review, analytical methods will be required. The need for methods that can be employed rapidly in the field by relatively untrained personnel is particularly evident.

Several levels of detection capability are required in the event of a spill. Initially, there is a need for methods to discover that a spill has occurred. Subsequently, if spilled agents are not known, they must be identified rapidly. Finally, the concentration gradients must be followed until they are below the critical concentration. The procedures required to achieve these ends must be available from a single source and easily accessible.

Existing Detection and Monitoring Procedures

One of the best monitoring systems to date for the discovery of spills is the ORSANCO Robot Monitoring System described in Appendix F. However, this system cannot specifically detect toxic materials and individual agents. The monitoring system reflects only general parameters such as dissolved oxygen, acidity, and conductivity.

Methods of detection of hazardous materials in water can range from human sensory observations of odor, discoloration, or slicks; to extremely complex techniques as in the case of many highly toxic soluble organic compounds. The diversity of the large number of hazardous materials further complicates this situation and, in the case where the pollutant is of unknown origin and nature, the problem is acute. In many instances, the first indicator of a pollution incident will be a fish kill.

Detection must be approached on two levels. In the case of a spill of unknown origin and nature, identification of the substance causing water quality degradation is the necessary initial step. For the identification of soluble organic compounds, one of the most generally applicable and reliable techniques involves comparison of infrared spectra to standard spectra. When several unknown components are present, gas chromatography can be employed to separate constituents for infrared analysis. The spectra comparison process can be automated through use of a computerized retrieval technique and can usually be accomplished within several hours.

On the second level, once the polluting substance is identified, either by reporting or other evidence, the need exists for analytical methods for tracing the extent and path of the pollutant and for gauging the effectiveness of countermeasures that may be taken. Here, emphasis is placed on rapid quantitative analytical methods that can be conducted in the field.

While mine safety tests and reaction tests have been developed for compounds in the gaseous and pure state, little work has been aimed specifically at similar identification methods in the aquatic environment. Testing is further complicated by the fact that natural waters are likely to contain interferring ions and materials.

Generally, most inorganics can be detected in the field with precipitation titration, or colorimetric tests at levels below critical concentrations. Exceptions to this include the highly toxic metals such as mercury, lead, nickel, and silver. Organic compounds are more difficult to detect. Spot tests can identify the presence of most amines, alcohols, ketones, esters, and aldehydes below critical concentrations with the exception of compounds having an extremely low critical concentration. Short chain aliphatics can be detected by commercially available portable gas chromatographs and moderate success with spot tests can be achieved with some organic acids and aromatic compounds.

Spot tests often require solvent extraction and mild heading to determine levels below critical concentrations. It was assumed that for low boiling compounds this could be achieved in the field. Techniques requiring elaborate equipment, excessive heat, or lengthy procedures were not considered as acceptable for field use in the development of the data in Appendix A.

Most halogenated hydrocarbons, and especially pesticides, are not detectable in the field at critical concentrations.

The results of reviews of detection methods and associated detection limits can be found in Appendix A, where both field and laboratory detection limits, suggested procedures, and the pertinent literature references are provided for the compounds ranked in the priority system. Tables following the computer print-out define detection limits, test procedures and literature reference codes. Field detection limits for all the compounds considered in the water use classification system are listed in Appendix C for purposes of comparison with critical concentration values. Laboratory tests selected for inorganic compounds were usually those outlined in Standard Methods.(84) Most laboratory tests for organic compounds consist of gas chromatograph determinations whose detection limits for each compound were found in recent publications.

Many organic liquids of low solubility and specific gravity may dissipate slowly enough to allow for initial detection on the basis of observations of a slick. However, many of these compounds are still soluble enough to be toxic and therefore disappearance of the slick will not indicate resolution of the problem.

Critique of Available Techniques

Monitoring systems such as those employed by ORSANCO are inadequate for the purpose of detection of hazardous materials spills. Toxic materials and individual agents are not specifically detected. The monitoring system reflects only general parameters such as DO, acidity, and conductivity. In many instances, changes in these parameters would not be evident even though a pollution incident has resulted in a major impairment of water quality.

While laboratory analytical techniques appear to be sufficient for identification of unknown contaminants, the equipment required is expensive and interference from constituents normally found in the receiving waters can cause serious time delays.

In many cases, presently available field detection techniques are too insensitive to detect contaminants at critical concentration levels, and they often require materials which are not readily available. Those techniques that are adequate are described in scattered sources which do not always contain sufficient information for conducting the test on waters of unknown composition.

Recommendations

Existing systems for continuous monitoring of water quality parameters are complex and costly. Moreover, such systems are inadequate for the detection and measurement of acute spills of hazardous materials. Therefore, it is recommended that in-stream monitoring including physiological and biochemical methods be developed to discover the presence of toxic materials in the aquatic environment. Exploratory work is being done in this field by Cairns at VPI.

Widespread deployment of continuous monitoring systems would be a costly undertaking. Furthermore, although spills of hazardous materials can occur anywhere, the need for complete monitoring of all waterways is not evident. Factors to be considered in determining the need for continuous monitoring at a particular site include: the historical frequency of spills, the nature of the materials involved in these spill incidents, and the water uses at the site. Therefore, it is recommended that areas with high spill frequencies be identified as well as the materials involved and the water uses. Monitoring stations should be established in those areas where frequent spills impair important water uses. These monitoring stations will act as early warning systems when spills or accumulated residues endanger water quality.

In order to alleviate analytical problems resulting from naturally occurring interferring substances frequently present in the aquatic environment, it may be advantageous to maintain a catalogue of infrared spectra of contaminant free waters. It is recommended that background spectra for naturally occurring constituents be obtained on a seasonal basis for selected waterways. Such background data can be used to adjust spectra obtained during spill incidents.

It is also recommended that studies be initiated to devise improved field detection techniques with high detection sensitivity for those substances which cannot presently be detected at critical concentration levels.

Finally, it is desirable that these detection techniques be catalogued and referenced for ready access by personnel involved in spill responses. It is recommended that this be achieved through use of a continuously updated manual drawing on information stored in an automated data bank.

ENVIRONMENTAL COMPLEXITIES

Brief

Chemical and biological constituents present in the aquatic environment complicate the problem of prediction of the fate of hazardous materials upon release. The magnitude of the effects that these constituents can have on spilled materials makes it mandatory that interactions in the environment be understood. While these effects cannot properly be introduced into a numerical formulation for priority consideration, they provide important background material for decision making and should lead to a better evaluation of the hazard associated with a given substance.

Presently, exchange, precipitation, biodegradation, and dispersion processes in natural water systems are understood to a degree of usefulness. However, processes of solid sorption and biological concentration are not as well understood.

Information regarding pollutant properties is at hand, but little quantitative data are available regarding the pertinent aquatic environmental characteristics controlling pollutant fate. Thus, the present information levels are but an initial step. They are nowhere near complete enough to establish specific data on chemical and biological effects of hazardous materials.

Knowledge regarding the chemical phase of the aquatic environment is more complete and at a stage of development which is more useful than the biological phase for predictive purposes. The state of knowledge with respect to an understanding of the interrelationships and interdependence between physicochemical and biological transformations is even less refined than that of the biological phase.

The solution to such problems is dependent upon extensive research designed first to detail and explain important biological and chemical phenomena, and then to utilize that information for establishing a comprehensive environmental fate testing program to which hazardous substances will be subjected. This would then provide the data base for critical concentration concepts.

The Need to Understand Environmental Factors

Efforts in the field of wastewater management and pollution control have led to the realization that the multiple chemical and biological species present in the aquatic environment interact with pollutants in complex manners. Determination of the ultimate results of these interactions is the only feasible way in which predictions can be made as to the effect the pollutant will have on the aquatic environment, and the fate of that pollutant once spilled. When pollution incidents are the result of acute spills of hazardous materials, information on the predicted fate and ensuing effects must be made available in a short period of time. Because of this time constraint and the obvious necessity to understand the interaction that will take place, there is a need for environmental testing of materials likely to be spilled prior to such an occurrence. Said environmental testing will rely heavily on a thorough understanding of probable physical, chemical, and biological interactions so that the proper system parameters can be designed into the testing program. Unfortunately, the required information cannot readily be obtained from mathematical formulations or theoretical hypotheses. Rather it must come as the result of direct investigations into the intricate relationship between chemical and biological processes in the aquatic environment.

Status of Present Knowledge

Processes which influence the fate of pollutants in the aquatic environment are outlined in Figure 6. As indicated in this figure, materials can be transported and dispersed largely through the action of turbulent mixing processes and currents, or they can be concentrated by biological and physicochemical processes. The physicochemical processes are tied to the biological processes of concentration in an intricate web of interrelationships about which little is known.

Dilution has classically been depended upon as the primary mechanism for control of the hazards of pollution. Dispersion and dilution mechanisms are fairly well understood and predictive models related to these phenomena have been developed for various watercourses. More general predictive models are available and can be applied in emergency situations where models specific to a spill area are unavailable. An example of one such model is presented in Appendix F.

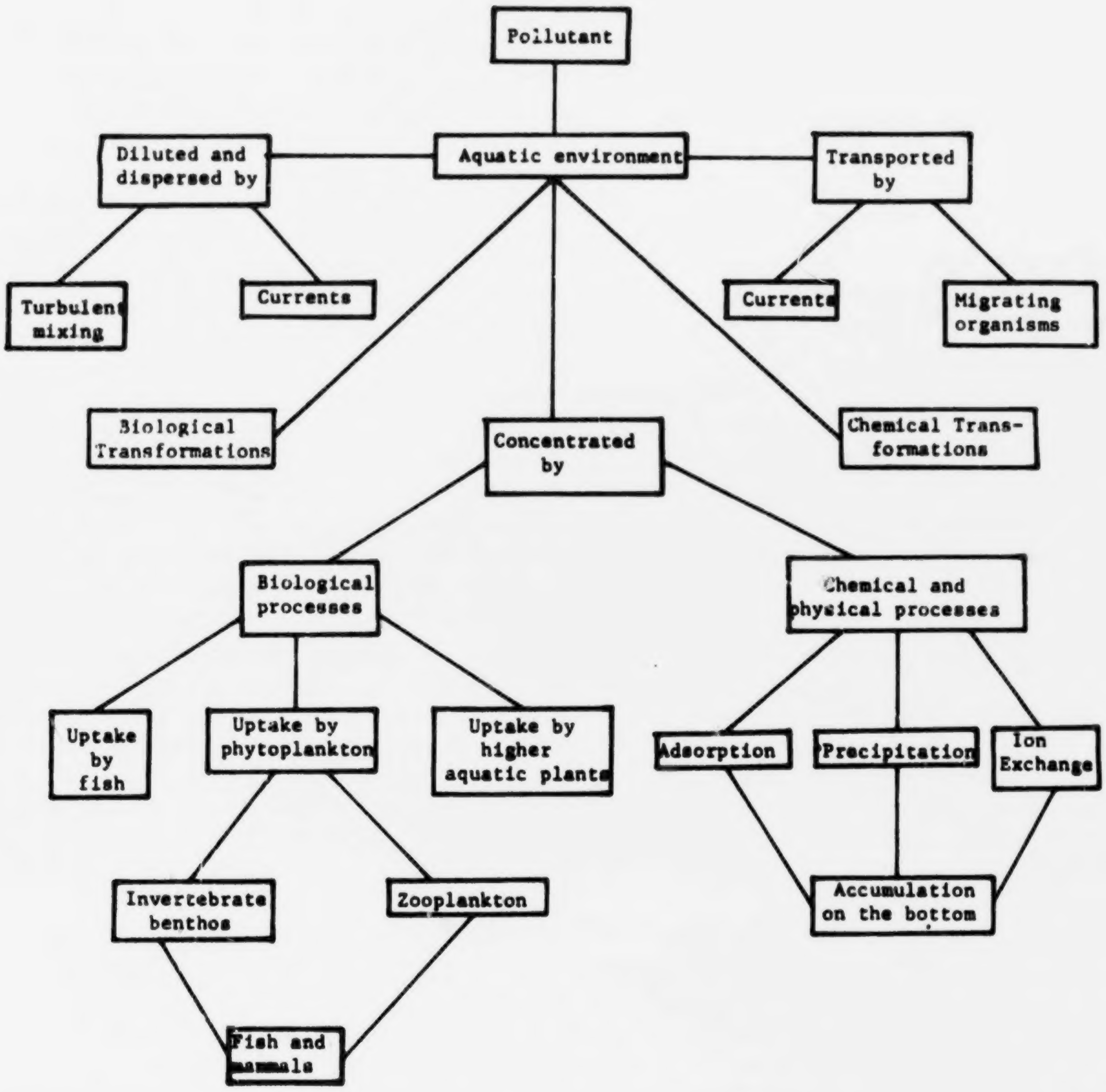


FIGURE 6. Processes Which Influence the Distribution and Fate of Pollutants Entering the Aquatic Environment [Modified from Ketchum(44)]

It is evident from Figure 6 that dilution is not the only natural process which works to alter the character of a spill. Pollutants may also be physically removed from solution and concentrated through precipitation, or sorption on the surface of sediments or suspended matter and through deposition as organic detritus after incorporation into biological tissue.

The extent to which chemical precipitation occurs is largely a function of compound solubility by solid phase properties, solution pH, ionic strength and associated ion types. All of these factors are well understood and in general can be measured in any given aquatic environment at any particular time.

The nature and extent of soluble pollutant sorption on the solid phase depends upon physicochemical properties of the sorbate and the solid phase, as well as solution parameters outlined above. Solid phase interactions in the aquatic environment have not been extensively studied and are not well understood. Knowledge of inorganic ion exchange reactions in the aquatic environment is farther advanced than that related to sorption processes of soluble organics.

Although sediments generally exhibit an affinity for organic and inorganic materials in solution, permanent removal from solution by known mechanisms can never be assured in the dynamic, natural ecosystem where changes are occurring which influence the reversibility of sorption reactions and the suspension of sediments.

Pollutants may be further affected in the aquatic environment as a result of chemical transformations. Transformations which alter the nature of pollutant materials can be inorganic or biological. Significant inorganic chemical transformations involve radionuclide decay, oxidation-reduction or hydrolysis. If solution parameters are known, these reactions can be predicted with reasonable certainty in surface waters. Biological reactions are considerably more complex.

Biological transformation may be of major importance in decomposing materials entering surface water in quantities nontoxic to the biota and under appropriate environmental conditions. Most microbial transformations have at least two common denominators, that is, the rate and extent of the transformation will be dependent upon environmental conditions and can be categorized according to direction. Biochemical degradation mechanisms may include dehalogenation, dealkylation, amide or ester hydrolysis, oxidation-reduction, ether fission, aromatic ring hydroxylation, and ring cleavage.

The rate, extent, and direction of microbial transformations are commonly dependent upon the predominant flora and fauna, the type and quantity of available energy sources, availability of essential nutrients, degree of aeration, temperature, moisture, pH, light, and the presence of toxic substances. Prediction of the fate of pollutants must therefore be predicted upon a knowledge of these environmental factors.

In addition to biological transformations, aquatic organisms may biologically concentrate materials present in the aquatic environment. Increasingly higher levels of concentrations are achieved as uptake proceeds through the food chain from phytoplankton through fish and mammals. A relative paucity of data exist in the area of biological concentration of most pollutants.

Critique

The individual natural processes detailed in Figure 6 are understood to varying degrees of sophistication. However, only dilution and chemical precipitation mechanisms are understood to the degree required. Knowledge related to various aspects of these processes has been developed by different sectors of the scientific community and is frequently not communicated between these sectors. The ability to develop a thorough understanding of the several natural processes will require an interdisciplinary approach.

Even if all of these individual natural processes were well understood, the interrelationships among them are so complex that the fate of most pollutants could not be accurately predicted. Consequently, environmental fate determinations must be made through experimental programs. Such an approach has been taken with DDT in recent years as discussed in Appendix F. However, this has proved to be a lengthy process for this single compound. Therefore, environmental factors must be better understood so that a quick and universally applicable environmental testing procedure can be derived. With such a tool, prespill data can be collected for postspill fate predictions.

Recommendations

In the light of the discussion above, a great effort is required to move beyond the present state of affairs into a position where environmental factors can be accurately assessed for spill situations. Because a significant portion of chemicals entering surface waters become associated with the suspended or sedimented particulate matter, initial research emphasis should be given to the role of the solid phase as repositories of noxious compounds, the fate of which may be controlled by manipulation of the particulate complex. Biological concentration should receive additional emphasis. A continuous culture of a group of organisms such as the blue-green algae categorized according to their potential usefulness as indicators of uptake of several chemical classes, responsive to low chemical concentrations, and amenable to rapid uptake measurements might be feasible for this purpose. Successful completion of this task should provide necessary environmental behavior information in the near future. It is suggested that at that time an extensive plan be designed for the determination of environmental fate of materials. Such a scheme would employ various organism and environmental conditions to determine toxicity concentrations and overall effects of hazardous materials. This might be carried out at a National Test Range site. It is further recommended that once such a test design exists, all new products should be subjected to testing as well as presently available commodities whose environmental behavior is not well understood.

To achieve these ends it is recommended that efforts be made to encourage interdisciplinary approaches and information exchanges in the area of environmental fate of pollutants. It is also recommended that these studies be directed first to those materials receiving high rankings in the priority ranking system described in Appendix A and then to the substances of lower ranking.

CONTINGENCY PLANNING

Brief

Present contingency plans on the national, regional, state, and local levels were reviewed and deemed inadequate for most materials other than oil. Industrial response plans in operation or planned were found to contain certain features superior to the National Oil and Hazardous Materials Contingency Plan. The former plans provide for more immediate response with a higher level of technical expertise specific to the substance involved. The latter plan and its regional subplans are more oriented toward the management and communications aspects and has its greatest strength in oil pollution control. The need for a blend of both public contingency plans and industrial response plans is apparent.

Ideally, a National Hazardous Materials Center under the control of a single agency should be developed in accordance with the NATIONAL PLAN to respond to all hazardous material related spills and disasters. This center would incorporate administrative features of the present National Plan with expertise and manpower from private industry to form an all encompassing contingency plan. The Center and the plan would then form the backbone for enforcement and regulatory activities in hazardous materials. Data developed in the course of these activities could be used to indicate research and development needs.

Needs and General Considerations

Emergency preparedness for disaster situations has long been recognized as an important and necessary defensive measure to minimize damages. Managerial and operational frameworks have been devised to meet various emergency conditions that may threaten life and property. More recently, the aquatic environment itself has been recognized as a resource that can be seriously damaged by accidents deriving from human activity. The TORREY CANYON incident, the pollution incidents at Laurel, Mississippi, and Dunreith, Indiana, and in the Santa Barbara Channel are lessons in point. Consequently, there is a well-recognized need for an emergency response system to enable rapid response to oil and hazardous materials spills. The National Oil and Hazardous Materials Pollution Contingency Plan of June 1970(56) lays the framework for such a posture.

To be effective, any contingency plan must outline all of the important steps involved in a spill emergency response and must also provide for the satisfactory execution of all related tasks. Such a process begins with the detection and reporting of the spill. Oil and other substances which impair the aesthetic qualities of water are detected quite readily by visual or other sensory means; soluble toxic materials, on the other hand, can possibly defy all but the most sophisticated analytical techniques. Unfortunately, natural in situ bioassay, i.e., fish kills, are frequently the first problem indicator. (Refer to Detection and Monitor Chapter.)

Potentially, this problem can be alleviated in part through conscientious reporting. If properly motivated, the person or organization responsible for the spill would immediately notify the proper authorities, thus eliminating the need for the initial detection step except in the case of accidental release without the spiller's knowledge.

Once an incident is reported, the approporiate response personnel must be notified. The report requires an effective communications system to alert all levels of command and to relay up-to-date information during the course of the response. Such a system should also aid in the dissemination of information to the public.

Beyond simple awareness that a problem exists, concerned personnel must have knowledge of proven countermeasures, and access to equipment, materials, manpower, and advisors. Knowledge of sources of detailed information on the exact nature of the threat and the resources that might be imparied must also be available. This necessitates a well-defined, in-place data bank and chain-of-command.

Finally, the plan must detail legal authority and financial responsibility to ensure that action is taken to expeditiously combat the problem without delays caused by considerations of the legal consequences which might ensue. This is further discussed in the chapter on legal and enforcement considerations.

It is apparent that any meaningful contingency plan must be both comprehensive and flexible at all levels. As a result of the need for detailed information concerning the spill site and available local resources, contingency plans become more and more effective as they detail to smaller and smaller political or geographical regions. Conversely, it would be both cumbersome and wasteful to duplicate the tremendous volume of technical information required to minimize the various hazards posed by the innumerable chemical substances handled and transported daily.

An overall national network detailing subdivision, responsible agencies, a national response center, communications systems, and men and materials available to augment local efforts is required. The national level organization would have three further responsibilities. It would provide leadership and coordination for all incidents crossing political and geographic regional boundaries or surpassing local capabilities. Secondly, it would review reports on all local actions and compile response information for effectiveness evaluations, policy changes, and recommendations on legislative action to reduce the frequency of spills. Finally, it would collect and continually update technical files on the physical properties, hazards, responses, and historical pollution incident reports involving hazardous substances. This information would then be available to assist local response personnel in making the proper response to a spill by taking advantage of prior experience in other regions.

Local levels of authority would structure the actual response mechanism and maintain data banks relative to their area, i.e., hazardous material production and traffic water uses, materials and equipment available, officials to be notified, and communication systems to be used. As the geographical area decreases, the plan would become more detailed, until the lowest subdivision would inventory all pertinent information for a response in that locale.

A typical multilevel approach is pictured in Figure 7.

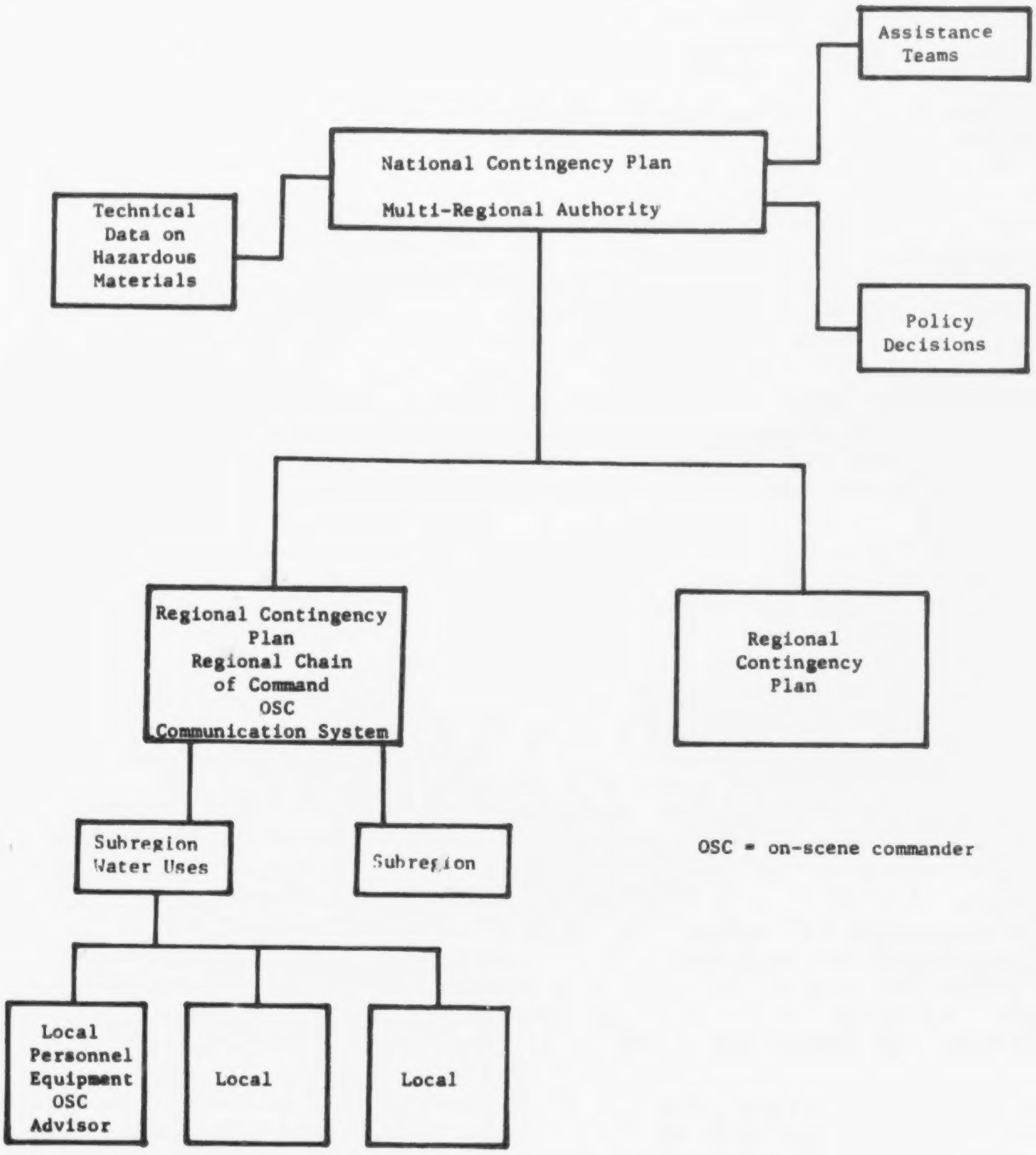

Assistance Teams
National Contingency Plan
Multi-Regional Authority
Technical Data on Hazardous Materials
Policy Decisions
Regional Contingency Plan
Regional Chain of Command
OSC
Communication System
Regional Contingency Plan
Subregion Water Uses
Subregion
OSC = on-scene commander
Local Personnel Equipment OSC Advisor
Local
Local

FIGURE 7. Administrative Structure and Inputs for Typical Contingency Plan

Present Contingency and Response Plans

Presently, there are a variety of contingency and response plans in effect. The National Oil and Hazardous Materials Pollution Contingency Plan is built upon a pyramidal structure drawing on regional, state, and local plans to provide an administrative network for response to spill situations. Industrial complexes have devised self-help cooperative programs such as that employed in the Kanawha Valley.(87) Industrial organizations such as the Manufacturing Chemists Association and National Agricultural Chemists Association have also designed response plans for use when hazardous materials are spilled. There are also specialized plans such as the Louisiana Waterworks Warning Network for dissemination of specific information during a period of poor water quality.(101) Representative examples of such plans are outlined in Appendix F. For a variety of reasons none of these plans is totally adequate for response to spills of hazardous materials.

Critique of Present Contingency and Response Plans

Although the National Contingency Plan and subsequent regional, state, and local plans profess to be "oil and hazardous material" programs, it is evident that the plans are at present scoped to deal principally with oil and petroleum spills. Equipment lists, personnel instructions, and handling techniques are largely geared to oil spill abatement. In addition, there are deficiencies in the overall structure of the plans. As a result, the systems are inadequate and ineffective in several vital areas for most hazardous materials incidents.

Once the spill has been discovered, the present contingency plan requires that the On-Scene Commander (OSC) determine the severity of the spill and the course of action required. This requires a large amount of information not always readily available to the OSC. For example, data detailing chemical toxicity in the aquatic environment, flammability, and explosive nature are nowhere catalogued in a compact form for ready reference. Even if such a compendium were available, the OSC would still be required to correctly identify the spilled compound and locate it in the manual. Due to the current multiplicity of common names, brand names, and technical names, it is quite possible that the OSC could not rapidly and accurately identify the compound, resulting in misunderstanding of the hazard involved and the countermeasure. This points to the need for a comprehensive information system to quickly relay pertinent information to the OSC upon request. Incorporated with this would be a cross-referencing system to assure identification of the correct compound. A numerical code identification key should be devised as suggested by the Manufacturing Chemists Association in the ChemTREC program.

Presently, the U.S. Coast Guard is undertaking the development of an information system of this type to aid Coast Guard personnel assigned as OSC for hazardous material spills. This system will serve only those areas under Coast Guard authority and, therefore, smaller bodies of water and nonsurface waters will not benefit. For example, the location of a past major accident at Dunreith, Indiana, would not be covered. This points to the need for development of a complimentary system to cover inland regions. Such a plan should be designed to be compatible with the Coast Guard information system.

Present response procedures focus major concern on fire and explosion hazards; the water quality aspects are often a secondary consideration. If equal concern were given to water quality aspects, steps could be taken immediately to initiate required stream monitoring and countermeasure procedures prior to the appearance of impaired aquatic life.

Lack of an adequate funding base is presently another deficiency of the National Plan. The assumption is made that the costs of control and restoration will be borne by the persons or organizations responsible for the spill. However, signatory agencies are now absorbing the remainder of the response costs out of existing budgets. The National Plan therefore warns that only those actions which can be undertaken with available funds should be initiated. This could potentially encourage agencies to shuffle responsibility in an attempt to minimize their own financial outlays and also suggests that inadequate responses could result from a shortage of available funds at the time of the spill. The existence of a revolving fund and a single controlling agency could eliminate these problems.

Industrial response programs which utilize information and communications systems and expert knowledge to aid on-site work come closest to meeting adequate response requirements. Once again, however, they frequently neglect the water quality aspects and present a series of partial answers not adequately bound together. The Manufacturing Chemists Association provides response information but no direct on-scene technical advice, while the National Agricultural

Chemists Association plan provides a technical field response team but does not provide immediate response information.

Recommended Plan

A logical first step toward an improved contingency plan would be the integration of present programs into a single overall system patterned in technical detail after the industrial systems backed up by the administrative and communications structure of the National Plan. Industrial participation in such a system is essential. The expertise in industry specific to a given material is invaluable.

To be effective, a pyramid structure beginning with local plans working upward to a national center similar to the present National Plan is necessary. The system should cover all aspects of spills with specific expertise assigned for protection of life, property, and total environmental quality. Experience gained in each incident should be channeled back to improve preventive measures and to identify successful measures and needed research areas.

In light of this, it is recommended that a single agency be given policy and research and development responsibility for hazardous-materials-related problems. This agency should establish a national center to house the pertinent data banks and administrative and technical personnel required. The system should maximize industrial participation through both information exchange and the designation of industrial personnel as consultants. While special funding will be required to maintain the center, funding of responses in industrial spill situations should be dependent on a reliable base.

It is recommended that all producers, handlers, and transporters of hazardous materials in quantities above a minimum volume be licensed with licensing partially dependent upon proof of financial responsibility in the event of a spill. In this regard it is suggested that the Federal government encourage the establishment of spill insurance policies. It is further recommended that Federal and State governments be self-insured against spills for which no liability can be assessed. Work should also be undertaken to evaluate the possibility of changing insurance policies to incorporate a no-fault structure at some time in the future.

It is recommended that the National Center be automated with provisions for quick information retrieval from governmental and industrial sources. The Center should operate so that actual spill response activities take priority with day-to-day administrative and regulatory activities prevailing in the interim.

COUNTERMEASURES

Brief

While prevention is the first line of defense against spills, it must be recognized that spills will occur and consequently, countermeasures must be available. Methods are available as a second line of defense for removing almost all water contaminants under controlled conditions. However, many of these techniques are not satisfactory for application in the aquatic environment. The answer to the problem of positive response to a spill must come from one of two directions: either new methods of treatment must be developed, or new methods for controlling the aquatic environment must be established.

However, at the present time, techniques for achieving these purposes in the aquatic environment are inadequate or non-existent. There is no single source of information on those techniques which may be applicable for a given pollution incident. There are uncertainties as to the secondary effects of those measures considered potentially effective (e.g., the environmental effects of sludges resulting from countermeasures may be more harmful than the original hazard).

To fill the gaps in the second line of defense, several steps are necessary. Work must be initiated in the area of control to develop new methods for containing spills before they reach surface waters. Techniques are required to contain contaminated waters after a spill. The ability to restore the aquatic environment must be developed and available. Finally, possible measures need to be catalogued and stored for ready access.

Existing Countermeasures

One of the least advanced of all of the technical areas related to spills of hazardous materials is that of physical-chemical response techniques which can be utilized to neutralize or remove hazardous polluting substances after they have been released to the aquatic environment. As a result of this dearth of information, cleanup and restoration of affected waters following a spill are in most cases left to the slow processes of natural dilution and biodegradation.

Eleven possible steps including defensive and offensive measures that can be employed in responding to a spill have been identified and are listed below.

A. Notify all water users on the receiving body of water, especially domestic water plants. In the case of moving streams, downstream users should be alerted in the same sequence as the progression of the spill from the initial site.

B. Physically remove all bags, barrels, and/or other containers that may still be leaking to the water body.

C. Add basic compounds such as sodium bicarbonate, sodium carbonate, or calcium hydroxide to neutralize acid conditions or suppress generation of reaction products.[1]

D. Add acidic compounds such as acetic acid to neutralize basic solutions.[1]

E. Add specific complexing, chelating, or precipitating agents for the formation of solids or compounds less toxic than the originally spilled contaminant.

F. Utilize large scale equipment to treat contaminated water in-place with powdered activated carbon, a coagulant such as alum, and a polyelectrolyte so that the resulting chemical floc precipitates the powdered carbon. Granular activated carbon can be added to water treatment plant filters. After the contaminant has passed, the carbon can be treated as a solid waste.

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[1] Other bases or acids could be employed. Those recommended were judged to have the least potential for creating detrimental side effects.

G. Physically remove flocs, solids and liquids which have sunk to the bottom. In some cases, this could possibly be achieved with equipment similar to swimming pool suction cleaning systems.

H. Boom and skim light solids or liquids floating on the surface. Oil removal equipment may be utilized.

I. Aid natural dilution to reduce concentrations to a level below critical concentrations by methods such as flow augmentation and mechanical mixing.

J. Contain spilled soluble materials so as to prevent diffusion throughout the aquatic environment. Most countermeasures are more effective with concentrated solutions.

K. Burn off floating volatile materials where air pollution and safety considerations permit.

Critique of Existing Countermeasures

Steps A and B are defensive measures which do not counteract the contaminant in the environment. Steps C, D, and E are potentially adequate actions. A danger exists in applying these latter measures in that the resulting compounds or precipitates may be more harmful to the aquatic environment than the original hazard. For example, silting in fish spawning and feeding areas, or increasing turbidities caused by secondary generated sludge constitutes a hazard. Such considerations must be taken into account for each individual case by evaluating the types of precipitates that will form and the environment which they will enter.

Step F is not completely satisfactory. While the granular carbon method is proven, it can only be employed where some type of treatment facility already exists and is dependent upon a ready supply of carbon. A possible exception suggests itself in the case of small streams. The Ohio River Valley Sanitary Commission(72) suggests damming small streams to skim off spilled oil. Water is allowed to pass under the dam through culverts. It may be possible to attach modular granular carbon units to these culverts to sorb soluble organics from the stream. Such a step would require considerable preparedness and quick action. The powdered carbon method is speculative. Not only is there no way to guarantee adequate contact and sorption, there is good reason to believe that the tremendous increase in the solids load might have effects as undesirable as those of the original compound.

Step G is also speculative. The swimming pool vacuum system may be a workable concept, but there is also a good chance that to effectively remove the contaminant, a large quantity of benthos would also have to be removed and handled. While heavy flocs and precipitates may prove innocuous enough to be left on the bottom, heavy liquids are a separate consideration. They pose a threat to water intakes which may be located near the bottom of a water source. In the event of a spillage, a substance such as ethylene dichloride would seek the bottom without dissolving.

Method H is an available technique for oil spills. It could be applied to light insoluble materials as well as slightly soluble organics. Rapid response aimed at booming and skimming any undissolved portion of the contaminant could greatly reduce the severity of the spill.

Method I can be applied only in certain circumstances. Mechanical mixers such as outboard motors can be used to augment diffusion. Flow augmentation may be utilized where stored water is available upstream. In any event, Method I is reliant in part on good predictive models of the aquatic environment to determine the extent of contamination and expected duration of toxic concentrations. Models of diffusion are illustrated in Appendix F. This information is available for a number of streams, as is time-of-travel data. Such data are not gathered in a single source nor properly referenced to allow for quick retrieval and application in a practical emergency.

Containment techniques (Step J) are not readily available for soluble materials. Earth moving equipment can be utilized to construct dams. Perhaps, formed in place, plastic dams can be developed. The technique requires a rapid response to minimize the contained volume.

Burn off techniques (Step K) are probably applicable only in very limited cases where the material remains confined in a small isolated area so as to minimize threats to safety and air quality.

Many substances now transported in bulk are soluble organics for which Methods C, D, and E are ineffectual. Some work has been done to develop substances which will chemically destroy toxic compounds. Lime and chlorine bleach solutions have been used on chlorinated hydrocarbons, particularly pesticides, under "dry spill" situations. In aquatic environments there is a good possibility that the lime and chlorine would be required in such large amounts that they would constitute an equal or greater threat to water quality than the compounds they are intended to destroy. Similarly, other reducing and oxidizing agents are often far too harsh to be introduced into the aquatic environment. Consequently, most of the compounds that are likely to be spilled cannot be counteracted effectively with state-of-the-art methods.

Even when substances do not pose a problem from a toxicity standpoint, they can threaten water quality by reducing the dissolved oxygen content. This can adversely affect aquatic life.

An alternative available for substances posing this threat is the introduction of oxygen to the water to maintain dissolved oxygen levels while the material is being dispersed and degraded aerobically. There has been recent interest in injecting air or pure oxygen into water courses to achieve this end in areas of chronic low dissolved oxygen.(94,102) The required apparatus is simple enough that mobilization for transport to a spill site should be possible. The problems would be those involved with supplying enough gas to accomplish the task and designing equipment that could efficiently transfer the gas into a variety of potential stream or reservoir configurations.

The computer output in Appendix A includes an alpha-numeric code for the Steps A through I which might be used to respond to a spill of the given compound. Appendix E contains a more detailed explanation of these steps for each of the compounds listed as soluble in the priority ranking. This listing also includes alternate names for the compounds and comments on physical properties which are pertinent to spill treatment, e.g., when a substance is slightly soluble and lighter than water, quick action with skimmers is desirable. Compounds listed as rejected substances should not require treatment unless low temperatures delay evaporation. In this case, skimming should be employed. Treatment of the heavy and light insolubles has been mentioned earlier.

Recommendations

It has been recognized that regardless of the adequacy of efforts to prevent hazardous material spills some spills will still occur. It is therefore concluded that effective countermeasures must be made available. Countermeasures which may satisfy the observed technique inadequacies and the lack of methodology for certain types of hazardous polluting substances are presented. These recommended countermeasures should be implemented using general objective guidelines such as:

A. Easily obtainable equipment and chemicals at reasonable costs.

B. Light in weight, easily transportable, and rapidly applied in both congested and remote areas, and safe to handle by untrained personnel.

C. Result in no reactivity problems causing secondary damage to the environment.

It is recommended that a detailed study of available precipitating and neutralization techniques to clearly delineate the hazards involved with aquatic reaction products be undertaken.

It is recommended that because there may be a great deal of promise in activated carbon technology that a detailed program should be instituted to conceive new application and retrieval methods for sorption treatment of waters subjected to pollution incidents.

It is recommended that techniques be developed to remove major portions of insoluble hazardous polluting substances and that a program be instituted to mitigate the damage to the aquatic environment resulting from dense liquids and flocs.

It is recommended that existing technology developed from programs such as the Advanced Waste Treatment Program of Federal Water Quality Administration be critically evaluated to develop any of these program elements into alternatives which have a potential benefit as an effective countermeasure for spills.

It is recommended that the existing predictive models and the time-of-travel (concentration) data be gathered and evaluated to provide the required data base and indicate where additional data on watercourses is required to afford the greatest protection of the public health and welfare during a pollution incident. These data and information-handling techniques should be readily available for emergency operations to quickly supply pertinent data for accurate prediction of the fate and effects of a hazardous polluting substance during a pollution incident.

It is recommended that detailed studies be undertaken to assess the environmental damage potential of ultimate disposal of hazardous polluting substances removed from the aquatic environment and to develop methods of ultimate disposal with minimum damage potential. Areas to be considered could include conversion of hazardous polluting substances to useful products; bio-stabilization, incineration and burial.

LEGAL AND ENFORCEMENT CONSIDERATIONS*

Brief

The practice of considering spills of hazardous polluting substances as a separate category of water pollution enforcement is a relatively new concept to most authorities involved in water pollution control. Until recently, hazardous polluting substances spills, whether occurring in production, transportation, storage, handling or use, were dealt with using laws and administrative structures designed to abate intentional and continual waste disposal from industries and municipalities. In a few cases, existing laws have been adequate to deal with spills. In most other instances, legal remedies, enforcement tools, and administrative procedures have not been adequate to achieve the desired preventive, punitive or corrective effects.

Even in the few cases in which enforcement measures have been taken as a result of spills of hazardous polluting substances, these cases have focused upon the recovery of legally demonstrable damages and cleanup costs--invariably a small part of the total environmental damage. Moreover, an undesirable shift of the economic burdens of the spill to the public sector has resulted when the total costs of the damage caused by a spill are not borne by the users or producers of the spilled product.

The study of State and Federal laws and enforcement experience has pointed out a number of alternative approaches which may be taken in striving for the optimal enforcement structure. From these approaches, the following concepts are considered to have the greatest potential for success in a Federally directed enforcement program.

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* Battelle does not perform legal research nor provide advice on legal matters. The findings and views in this section and Appendix I therefore reflect work conducted by Environmental Planning Associates and represents that organization's research by interview with persons in several Federal and State agencies.

1. A specific prohibition against discharges of hazardous polluting substances should be included in Federal law.

2. Regulations which define specific hazardous polluting substances, their levels of toxicity, and the precautions which must be taken in their use in order to prevent damage to the water environment, must be developed, promulgated and enforced by a single agency of the Federal Government. These regulations should cover any aspects of use, transport, handling or storage which present an imminent danger to the aquatic environment.

3. Persons responsible for a hazardous polluting substance spill should be required by law to notify the appropriate authority immediately. Civil and/or criminal penalties should be imposed for failure to notify.

4. Liability imposed should be a function of the severity of the hazard involved. High-hazard materials should carry absolute liability, and other hazardous materials strict liability. Liability for damages, cleanup and restoration costs should be unlimited in either case.

5. Financial responsibility should be required for the producers, users, handlers, transporters, and storers of hazardous polluting substances, through insurance, bonding or other means. Levels of financial responsibility should be dependent on the hazard of the material involved, and should be sufficient to cover the costs of any potential spill situation.

6. The designated agency should have the authority to assess civil penalties for violation of hazardous polluting substances regulations. Assessment of penalties should be dependent on the degree of fault involved in a spill, but a showing of intent should not be required.

Background and Critique of Legislative and Judicial Experience

Federal Experience

Existing Federal laws which have or potentially may have an effect upon the discharges of hazardous polluting substances are reviewed in the section on Federal Law in Appendix I and include:

- Federal Water Pollution Control Act, Section 10
- River and Harbor Act of 1899 (Refuse Act)
- Various regulatory powers principally exercised by department within the Department of Transportation applying to the methods of transportation of hazardous polluting substances
- Other Federal legislation such as administered by the Department of Agriculture and Federal Food and Drug Administration.

Since the primary focus of Federal legislation has been on the continuous discharge of pollutants or is on safety aspects, existing Federal legislation is rather poorly equipped to deal effectively with spills of hazardous polluting substances. Critical comments on some of the above laws are as follows.

The Federal Water Pollution Control Act enforcement provisions have obviously been designed to effect the abatement of continuous, chronic discharges. Cleanup and restoration liability is questionable under the Act. Moreover, no authority is available to administer preventive measures on hazardous polluting substance producers, carriers, storers, or users.

The River and Harbor Act of 1899 (Refuse Act) is a criminal statute, under which, immediate civil injunctive relief is available; moreover, the statute has been interpreted by the courts to prohibit the discharge of any foreign or polluting matter into the navigable waters of the United States without a permit from the Corps of Engineers. However, litigation is presently required to effectuate its mandate, and minimal preventive regulatory powers may be exercized under its authority.

The effectiveness of regulatory authority administered by Department of Transportation and other departments over transport and handling of hazardous polluting substances has been principally concerned with public safety; environmental effects have been ignored or given only cursory consideration. The regulatory powers are also divided among many agencies, and enforcement has been irregular.

State and Other Laws

States have enacted various types of legislative programs desgined to deal with water pollution control and water quality (State Law Section, Appendix I). As with Federal programs, the topic of hazardous polluting substance spills has not, with few exceptions, been given specific and/or separate treatment. In general, States have three separate categories of statutory regulation which may be applicable to this area.

State water pollution control laws, centering around water qualtiy standards, a discharge permit system and/or health and welfare regulations, have been formulated and applied principally to continuous discharge situations, with few applications to the spill of hazardous polluting substances.

Fish and game laws exist which impose penalties and/or require compensation when fish or animals are killed by water pollution. In this area, some penalties and damages, principally fish restoration costs, have been assessed and recovered when spills of hazardous polluting substances have occurred. However, the laws in this area are directed toward a very specific area and can be applied only when fish or other animals are killed.

In addition, some State regulation of transportation and storage of hazardous polluting substances exist. Again, like the Federal regulation in this area, enforcement authority is divided among several agencies and directed almost entirely toward maintaining public safety; environmental effects are inadequately considered. In the area of transportation, States often adopt Federal regulations by reference.

Jurisdictional Experience

Federal Versus State Jurisdiction. In pollution control under the Federal Water Pollution Control Act, Federal authority extends over coastal, interstate, and navigable waters, with the provision that interstate effects of pollution must be shown. The Refuse Act also gives the Federal Government authority to enforce its provisions over all navigable waters. Navigable waters have been defined very broadly to include those streams or rivers which, either in their natural or improved condition, will float a light boat or log, and includes the tributaries of such waters. Most waterways in the United States are therefore subject to Federal action under the Refuse Act and the Federal Water Pollution Control Act, although subject to State constraints in the latter statute. Many State officials have felt that, even though legislation may give the Federal Government authority to act in cases involving intrastate waters, such action should be deferred to the States--except in instances where inactivity by the State has resulted in a dangerous or harmful condition. The absence of cooperation between State and Federal pollution control authorities especially in cases of overlapping jurisdiction, has led to conflicts and redundancies in enforcement.

Interagency Jurisdiction. A second jurisdictional problem arises within States, where aspects of water pollution which are regarded as involving public health and safety and those concerned with aquatic and wildlife and natural resources are given to separate agencies. Primary authority is vested in one agency, generally in the Department of Health, with the wildlife or conservation agency responsible only where fish or wildlife are involved. This division of authority can create problems of jurisdiction over pollution incidents; however, in most cases excellent cooperation between the respective agencies avoids many of the potential problems.

An obvious answer to the question of jurisdiction within the State is to place all authority and responsibility within one organization with enforcement powers over all pollution situations. The New York State Department of Environmental Conservation has combined the enforcement personnel from the former Department of Conservation and from the Department of Health into a new organization with combined authority. This reorganization is similar in scope to the Federal Environmental Protection Agency.

Role of Legal Counsel

Although most claims are settled in pretrial negotiations, court proceedings must sometimes be instituted to settle damage claims. In many states, action for recovery of damages to waters of the State may be initiated only by the State (for example, California and Louisiana). In instances where an assistant attorney general is assigned the responsibility for environmental matters, such prosecutions may constitute a small portion of his responsibilities. A more satisfactory arrangement appears to be the full time assignment of an assistant attorney general to the appropriate enforcement department, with the sole responsibility of providing advice and prosecuting cases for the department. In this instance the assistant attorney general becomes familiar with the problems of enforcement, and has a greater opportunity for assisting the enforcement officers, who are generally technically oriented, in developing methods of more effective investigation and prosecution.

Another alternative, which may be perhaps the most effective, is the placement of a "house counsel" within the appropriate enforcement department. The house counsel usually is responsible directly to the head of the department. In this case counsel should have authority to settle and prosecute cases in the lower courts, either directly or through local district attorneys. Cases in the higher courts would probably have to be tried under authority of the attorney general. An organization with a house counsel is likely to be more legally oriented. At the present time, most enforcement officials are technical people with little legal training. Increased reliance upon litigation on pollution cases would result in more effective enforcement.

Discussion and Recommendations for Legislation and Enforcement

Federal and State Roles in Legislation and Enforcement

Federal legislation and regulations relating to water quality impairment caused by spills of hazardous polluting substances is desirable, for the following reasons: (1) Many spills affect navigable and interstate waters. (2) There is a necessity to avoid conflicting and uncoordinated regulations. (3) There are large amounts of hazardous polluting substances transported in interstate commerce.

Federal jurisdiction over and control of navigable and interstate waters of the United States is constitutionally authorized, well established, and widely recognized.

Enforcement programs are not necessarily effective or ineffective solely because of the strength of the law. It should be recognized that an attitude which stresses the importance of environmental quality is also necessary to a well-founded program. It is therefore suggested that Federal and State water quality officials work closely together to develop an integrated system to include Federal legislation, State legislation, and a complete set of unified regulatory provisions.

With the exceptions of oil, radioactive substances, and pesticides, few state water quality officials view spills of hazardous polluting substances as a cause for inordinate concern (see Appendix H); nevertheless, all water quality officials agree that specific legislative recognition of the potential for water pollution by such spills could be beneficial to an enforcement program.

Some states which perceive the hazardous polluting substance spill problem to be serious are already taking major steps to prevent incidents, as in the case of Pennsylvania. In certain agricultural states, however, concentration on eliminating the threat from spills of pesticides and fertilizer is more important, and implementation of a program similar to Pennsylvania's has not been considered necessary because the spill experiences have not been similar. The nature of the hazardous materials spill problem, therefore, has been considered partially area-dependent.

Most State officials indicated that they would be pleased to receive technical information on hazardous materials from Federal sources. Examples of such information are found below in the section entitled "Evidentiary Problems of Enforcement." Also favored are recommendations on how to prevent spills and how best to react to a spill, given a limited number of enforcement and investigative personnel. With such information, more responsive state and local programs can be tailored to particular conditions and problems.

Federal experience in pollution control, for example, in the establishment and enforcement of water quality standards, provides an indication that some states may not take sufficient action regarding hazardous polluting substance spill prevention and control. Where the beneficial water uses of such a state are endangered, the designated Federal agency should have the authority to take a more active role in the state pending development of an appropriate prevention program. This "management by exception" approach would reduce the size of the Federal organization necessary to carry out the total enforcement program which is developed.

While seeking maximum cooperation from the various states in the prevention of and reaction to spills of hazardous polluting substances, the Federal government should develop a strong legislative program for those waters included in its cognizance. This program should result in regulations which will be enforced by the Federal government and may be adopted by the states where applicable. Furthermore, there are several program areas which, by the nature of the problem involved, are necessarily the subject of Federal action, at least at the outset. These areas include, for example, the regulation of hazardous pollution of substances carried or flowing in interstate commerce, spills involving Federal waters, development of centralized reporting, classification, and insurance or financial responsibility schemes. It can be recognized that, as legislative and administrative program development at the Federal level matures, relatively more responsibility may be transferred to states. Some specific considerations on the nature of desirable Federal legislation are presented in the sections which follow.

Prevention of Incidents

The primary value of any legislation or regulation directed at spills of hazardous polluting substances lies in the ultimate prevention of pollution incidents. Most enforcement agencies are authorized to act only after an incident has occurred. This means of coping with the problem, while direct, is alway's time-consuming and invariably results in damage to the environment which is virtually irreparable such as polluted water, dead fish, destruction of other aquatic organisms, and public inconvenience.

After-the-fact investigations and prosecutions of pollution incidents, in and of themselves, do little to prevent future accidents. There are a number of reasons which contribute to ineffectiveness of after-the-fact enforcement, including: (1) Notification of discharges of hazardous polluting substances, if they are received at all, are not usually received in a timely manner by officials who can investigate the spill and effectively coordinate cleanup operations. (2) There are a limited number of qualified personnel available to conduct necessary investigations and collect evidence required. (3) Prosecuting authorities cannot accept every case for action, and must therefore choose those which represent the most serious breaches of the law; relying largely in the demonstration effect of successful prosecutions to deter future violations. (4) In cases involving spills of hazardous polluting substances, the courts will continue to have latitude in determining guilt and assessing civil or criminal penalties. (5) Continuous broad scale monitoring of water quality is not appropriate to detect all hazardous substance spills.

Enforcement which takes place after an incident is a relatively unproductive activity in this context and should be minimized within a comprehensive spill reduction program by requiring effective preventive measures. An example of such a program is Pennsylvania's Pollution Incident Prevention Program (see Section on State Laws, Appendix I).

Evidentiary Problems of Enforcement

In taking cases of hazardous substance spills before the courts, enforcement officers must often prove that a material spilled by a defendant is in fact hazardous to some use of a body of water and is therefore a pollutant. If damages occur which can be directly attributed to the spilled material, the task of proof in civil proceedings is relatively simple. In criminal proceedings, however, which do not necessarily involve recovery for damages, the enforcement agency must be able to prove that a material is in fact harmful in the quantity involved. Based on interviews with enforcement officials, it is recommended that a useful enforcement tool would be a complete evaluation of those materials determined to be most likely to cause pollution problems, including nature of pollution problem, toxic or harmful concentration limits, related synergistic effects, and proper handling methods. This listing, which would probably be the result of an extensive research effort, could be published by the Federal Government, and thus serve as evidence in proceedings of any State, local, or Federal court.

Legal action for recovery of damages may require proof that a specific pollutant caused death of a fish, bird, or other animal. In many cases where biologists are called upon for expert testimony, they are unable to state conclusively that a substance found in a stream or in the tissues of an animal was actually the cause of death. Presence of a toxic material in an animal, unless backed up by valid scientific evidence, amounts to no more than circumstantial evidence, and has little or no weight in criminal proceedings. Based on interviews with enforcement officials, it is recommended that a program be conducted at the Federal level which would investigate the effects of the most likely pollutants on those species which are commonly affected. This program could derive lethal limits of hazardous substances on the valuable species, as well as develop diagnostic techniques for determining causes of death, i.e., presence of a given concentration of some pollutant in certain tissues or blood of an animal is positive proof that death resulted from contact with that pollutant. As in the case of definitions of hazardous materials, these data, published under authority of the Federal Government, could serve as scientific authority to back up a case in a court of law.

Other technical problems in enforcement which are discussed in preceeding chapters include: inability to collect reliable samples of contaminant or contaminated water after a spill; and the difficulty of tracing a pollutant to its source, and proving in court that such determination was valid.

Spill Liability

The public should not be required to pay any of the costs associated with damaging discharges of hazardous polluting substances. Where it has not already been done, cognizant water quality authorities at all levels of government should be granted authority to recover, in civil action, all cleanup, restoration, and investigation costs. Federal legislation should spell out in some detail those types of costs which are to be recoverable.

The assessment of damages resulting from a hazardous material spill is relatively simple when damages to property and visible aquatic life and wildlife alone are considered. Property is generally assessed at repair or replacement cost, and is handled by the civil courts. Large or visible fish and wildlife are assessed, by size and species, according to some measure of their value. In Pennsylvania, fish are assessed at hatchery replacement cost. In Ohio all wildlife are assessed at the wholesale market value. Costs of investigation and prosecution are often included in the damage assessment.

An unsolved problem in assessing damages from a spill is determination of the value of the aquatic biota in a stream or river. The true loss of value from a single, catastrophic spill, from the time of spill until restoration is complete, is undoubtedly far greater than can be determined by body counts of dead wildlife at the time of the spill. Loss of much of the food chain--algae, grasses, insects, bacteria, and other minute elements--will certainly have a long lasting effect on the viability of more visible and directly valuable wildlife--game fish, shellfish, birds, and water-feeding mammals. Enforcement officials agree that a means for considering long-term effects caused by loss of food chain organisms should be employed in assessing damages. To the best knowledge of the officials contacted, however, sufficient scientific data are not available on which to base such an assessment. It is recommended that development of techniques for assessing this "long-term damage" would enable enforcement officers to compute a more realistic damage figure than is now possible.

Because proof of damages is so difficult and damage to the aquatic environment is much more pervasive than can be legally demonstrated using customary evidentiary concepts, cost recovery should be liberally allowed. The initial determination of liability and damages should be made within an agency having expertise in the water quality area, with appeal rights limited to ordinary civil courts.

The mere existence of damage due to a spill should be sufficient to establish liability for costs, except where an act of God, an act of war, or an act of a third party can be proven to have caused the pollution. For a few high-hazardous materials, to be defined by regulation, there should be a statutory provision which establishes absolute liability for any impairment of water quality. Materials in this class should be defined by the agency indicated above. In all cases of spills of hazardous polluting substances, the burden of proof should be on the party charged with responsibility for or control of the hazardous substance. Liability in cases involving spills of hazardous polluting substances should be unlimited, i.e., the responsible party should be liable for all damages, cleanup costs, restoration costs, and investigation costs. Civil penalties above and beyond recovery of cleanup and restoration costs should also be provided by statute, at least for cases in which willfulness or negligence is involved. Regulations developed by the cognizant agency should be used to provide the guidelines for determination of the amount of the fine for a particular hazardous polluting substance and set of circumstances. The fine should be assessed by the cognizant agency, with rights to appeal decision to the courts in cases of arbitrary or capricious decision.

Financial Responsibility Requirement

Federal regulations should establish financial responsibility requirements for manufacturers, users, handlers, carriers, and storers of various hazardous materials. These requirements should be developed by the water quality agency given statutory authority to do so. The purpose of the bonding will be to provide assurance that costs incurred by government agencies and others in case of an accidental spill will be repaid. The amount involved should vary for each material, being dependent on the potential for water damage. The impossibility of monitoring everyone using or transporting a hazardous substance is recognized; however, spot checks might be used to enforce bonding requirements, and criminal or civil penalties for failure to comply with financial responsibility requirements could be employed to ensure compliance.

As an alternative or a supplement to financial responsibility requirements, a Federally underwriten or sponsored compulsory or voluntary insurance program might be employed. Since private underwriting capacity in this high risk area is virtually unavailable, Federal participation in some form would be necessitated. An advantage of introducing Federal insurance in this area would be the ability to effect prevention standards in hazardous polluting substances industries through the rate structure. This device would be particularly effective where the insurance was made involuntary.

Private Actions: Private actions to recover damages are limited to Common Law tort recoveries for direct personal or property damages or private nuisance actions; in addition, the possibility of private citizens bringing *qui tam* actions (see Private Rights of Action Section, Appendix I) under the Refuse Act has recently been tested in Federal courts. No resolution of this standing issue has yet been accomplished. Citizen suits, in individual as well as class action form, should be specifically authorized in Federal and State legislation so as to generate increased enforcement efforts.

Failure to Notify

A civil or criminal penalty should be assessed for failure to report the spillage of a hazardous material into water. Because hazardous materials vary greatly in inherent threat to the environment, a single maximum penalty should be authorized in the law, with the amount in each case having some relationship to the magnitude and potential damage of the spill. Repeated or intentional violators should be more heavily penalized. Administrative provisions of this penalty must be carefully developed, so that the fact of notification cannot be used to avoid liability for the spill itself. For example, where a criminal penalty is imposed for failure to report, criminal sanctions for the spill itself could not be employed.

Responsible Federal Agency

It is recommended that information pertaining to the potential effects of hazardous substances on water quality be channeled to the states through a single Federal agency which will correctly assess environmental considerations of spills heretofore ignored or given minimal treatment. The designated agency should be granted statutory authority to develop and promulgate regulations on hazardous materials--regulations which have the specific objective of water quality. It should set bonding requirements, publish information on hazardous materials, assist in certain and development of contingency plans including a central information/notification network, and work with other Federal regulatory agencies in coordinating and rationalizing all regulations dealing with the transport, storage, use, or production of hazardous polluting substances. Through the designated agency, information could also be disseminated on such State developments as Pennsylvania's PIP program, Louisiana's waterworks warning network system, and new hazardous polluting substances which appear on the market, with the further goal of developing and encouraging the adoption of uniform State legislation in the area.

Scope of Legislation

Initial Federal legislation on hazardous materials need not be concerned with specific substances. Any substance which acts, upon entering or combining with water, to impair a beneficial use of the water could be defined as a hazardous material. For purposes of legislation, the materials may be defined in terms of results and hazard categories may be specified. As noted above, authority should be delegated under the law to a single regulatory agency to set specific standards for the various hazardous polluting substances, stressing the environmental effects of spills into water. If a particular substance becomes so inherently and obviously dangerous that it represents a serious threat to water quality, special attention may be given to it in a statute. In such a case, legislation pertaining to oil spills provides an example.

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APPENDIX A

PRIORITY RANKING SYSTEM OUTPUT

Appendix A is comprised of the computer printout for the priority ranking system. The first listing is the name of all the compounds and classes of compounds rated by the system.

The second listing rates these compounds by QI, the quantity in shipment or produced each year. This listing provides a means of comparison of hazardous materials purely on the basis of the quantity of each being transported annually. This alone might be valid if each transport mode had the same probability of having an accident and the resulting spills would be evaluated as equally severe. Unfortunately, this simple formulation is not realistic.

To modify the quantity figures into rating numbers significant of the threat each hazardous material poses to the water environment, the numerical formula presented in the report section on classification systems was devised. The new rating utilizes accident probability figures and threshold concentrations to proportion the production quantities into rating numbers sensitive to transport modes and the severity of a spill should it occur. The quantity modification is made through the use of the equation;

$$Q = QI[(p_w \cdot f_w) + (p_r \cdot f_r \cdot a_r) + (p_t \cdot f_t \cdot a_t)]$$

where QI = the annual production quantity of the compound

p_w = probability of any barge shipment resulting in an accident = 0.0028, a number derived from the total number of hazardous materials related barge accidents and total number of barge chemical shipments in 1968.

f_w = percentage of the compound shipped by water

p_r = probability of any rail shipment resulting in an accident = 0.0011, a number derived from the total number of hazardous materials related rail accidents and the total number of rail chemical shipments in 1968.

f_r = percentage of the compound shipped by rail

a_r = fraction of major railways near surface waters = 0.3, a number derived from mapping rail routes and waterways between major cities in each region of the country.

p_t = probability of any motor truck shipment resulting in an accident = 0.019, a number derived from the total number of hazardous materials related truck accidents and the total number of truck chemical shipments in 1968.

f_t = percentage of the compound shipped by motor truck

a_t = fraction of major highways near surface waters = 0.3, a number derived from mapping truck routes and waterways between major cities in each region of the country.

The results of this system are in the second listing.

All compounds of low boiling point, low solubility, and low density (SpG <1) are listed under the format "Rejected Substances." This category includes two substances which are reaction products of listed compounds and water: hydrogen sulfide, and calcium hydroxide.

The second category includes substances of low density whose solubilities are too low to permit toxic concentrations to be reached. The third category is comprised of similar compounds whose densities are greater than one. These are ranked by the adjusted quantity Q.

The final category contains the compounds that pose the greatest threat to the environment, the soluble hazardous chemicals. They are ranked on the basis of Q/critical concentration.

Following the listings, the input data cards are listed in the same order as they were ranked. The data may be read out using the following placement scheme. The scheme is also illustrated in Figure A-1.

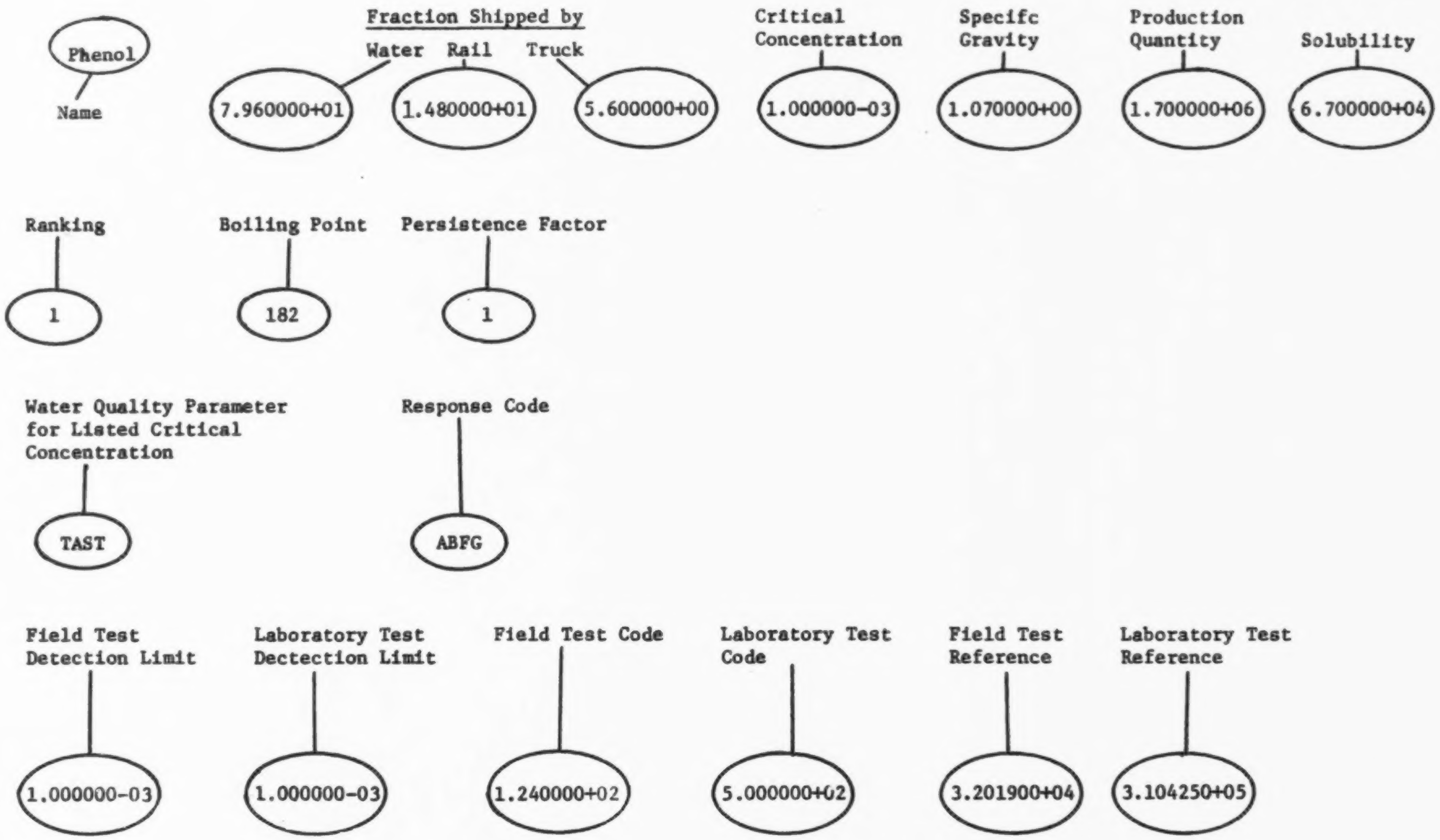

FIGURE A-1. Key to Reading Computer Printout

Line 1

Name of Hazardous Material

Line 2

[Fraction Shipped by Water] [Fraction Shipped by Rail] [Fraction Shipped by Truck] [Critical Concentration] [Specific Gravity] [Annual Production Quantity] [Solubility]

Line 3

[System Ranking] [Boiling Point] [Persistence Factor]

Line 4

[Critical Concentration Code] [Restoration Code]

Line 5

[Field Detection Limit] [Lab Detection Limit] [Field Test Code] [Lab Test Code] [Field Test Literature Reference] [Lab Test Literature Reference]

These are individually explained below.

Name of Hazardous Material - compound or class of compounds. Classes of compounds are broken down into individual components in Table A-1 after the printout.

Fraction Shipped by Water - the percentage of a compound transported by barge

Fraction Shipped by Rail - the percentage of a compound transported by rail

Fraction Shipped by Truck - the percentage of a compound transported by motor carrier

Critical Concentration - the lowest threshold concentration of the four water quality parameters: human toxicity, aquatic toxicity, plant toxicity, and aesthetic effects, given in mg/ℓ.

Specific Gravity - listed value.

Annual Production Quantity - the most recent figure available on the quantity of each compound shipped, sold, or produced annually, in that order of preference.

Solubility - listed solubility in water at 20°C in mg/ℓ. When no figure was available, even orders of magnitude were used e.g. 10, 100, 1000 to allow comparison with toxicity thresholds that were known. Hence, even though the solubility is not correct, it is greater than or less than the critical concentration as it should be.

System Ranking - the rank assigned to the priority rating.

Boiling Point - the listed value with 99999 used when the real value was not available.

Persistence Factor - an integral value used to identify persistence.

0 - compound will probably not last 24 hours in open environment

1 - compound or its reaction product with water will last long enough to allow for some kind of response action

2 - compound is reaction product with no production quantity of its own. (Quantity figure is that of reactant.)

Critical Concentration Code - code denoting the source or water quality parameter involved with the critical concentration used.

DOME - domestic water supply standards (usually USPHS standards).

FISH - fish toxicity for common species or game fish. This may be a TLm or a minimum distress concentration depending on the data available.

TAST - minimum taste or odor threshold.

COLO - concentration required to color water.

AQUA - TLm for aquatic life, no fish data available.

CROP - concentration in irrigation water at which crops would decrease in quality or yield.

H2S, HBENZ, ACID etc. - reaction product when compound comes in contact with water. Critical concentration is derived from reaction product's toxicity characteristics.

Response Code - letters refer to individual neutralization steps that can be taken as outlined in the section on Countermeasures. A "Z" indicates response is deemed feasible and adequate at this time to reduce contaminant below toxic levels.

Field Test Detection Limit - the concentration in mg/l at which a compound can be detected with a simple test amenable to operation in the field.

Laboratory Test Detection Limit - the concentration in mg/l at which a compound can be detected with laboratory equipment.

Field and Laboratory Test Code - refers to the test listed in Table A-2.

Field and Laboratory Test Reference - the first two digits refer to the book or article listed in Table A-3. The zero is a divider, while the last digits give the number of the page where the information occurs.

Computer Printout:

```
DIETHANOLAMINE
ETHYLENEDIAMINE
METHYL ETHYL KETONE
ACETONE
ACETALDEHYDE
ACETONE CYANOHYDRIN
VINYL CHLORIDE
PROPYLENE DICHLORIDE
CARBON TETRACHLORIDE
ETHYL CHLORIDE
FORMIC ACID
PROPRIONIC ACID
FATTY ACIDS
CALCIUM HYDROXIDE R
ESTERS OF MONOHYDRIC ALCOHOLS
CITRIC ACID
SODIUM ACETATE
OXALIC ACID
ZINC ACETATE
AMMONIUM ACETATE
DIBUTYL PHTHALATE
METHYL METHACRYLATE
ETHYL ACRYLATE
BUTYL ACRYLATE
2 ETHYLHEXYL ACRYLATE
ALCOHOLS, MONOHYDRIC, UNSUBSTI
METHYL ALCOHOL
DECYL ALCOHOL
HEXYL ALCOHOL
ISOOCTYL ALCOHOL
ETHYL ALCOHOL
ISOPROPYL ALCOHOL
BUTYL ALCOHOL N AND ISO
N-PROPYL ALCOHOL
PROPYL ACETATE   ISO-N
N-BUTYL ACETATE
ETHYL ACETATE
ISOPROPYL ACETATE
POLYHYDRIC ALCOHOLS ESTERS + E
DIETHYLENE GLYCOL
DIPROPYLENE GLYCOL
TRIETHYLENE GLYCOL
SORBITOL
ETHYLENE GLYCOL
PROPYLENE GLYCOL
BENZALDEHYDE
ACETOPHENONE
ANILINE
CRESOLS  TOTAL O,M,P.
```

CUMENE
CYCLOHEXANE
CYCLOHEXYL ALCOHOL
CYCLOHEXANONE
DIVINYL BENZENE
ETHYL BENZENE
NITROBENZENE
PHENOL
PHTHALIC ANHYDRIDE
DODECYL BENZENE
FURFURAL
BENZOYL PEROXIDE
BENZENE
DYES   TOTAL
MORPHOLINE
DINITRO ANILINE
NONYL PHENOL
PYRIDINE
TOLUENE
CHLOROBENZENE
DICHLOROBENZENE O,P.
BENZYL CHLORIDE
NITROUS OXIDE
MAGNESIUM CPDS
CALCIUM FLUORIDE
CALCIUM NITRATE
BERYLLIUM DUST
AMMONIUM PERCHLORATE
CALCIUM CARBIDE
SODIUM METAL
ACETIC ANHYDRIDE
ACETIC ACID, SYN.
PHOSPHOROUS OXYCHLORIDE
PHOSPHORUS TRICHLORIDE
PHOSPHORUS PENTASULFIDE
CALCIUM HYPOCHLORITE
CHLOROSULFONIC ACID
PERCHLORIC ACID
FERROUS SULFATE
ANTIMONY CPD
POTASSIUM CPDS
POTASSIUM SULFATE
POTASSIUM IODIDE
POTASSIUM HYDROXIDE
SODIUM CPDS
SODIUM HYDROXIDE
SODIUM CARBONATE
SODIUM SILICATE
SODIUM SULFITE

SODIUM SULFIDE
SODIUM SULFATE
SODIUM PHOSPHATE
SODIUM HYDROSULFITE
SODIUM FLUORIDE
SODIUM CHLORATE
SODIUM BORATE
ARSENIC CPDS
COPPER SULFATE
LEAD CPDS
LEAD ARSENATE
NICKEL CPDS
MERCURY CPDS
ZINC SULFATE
CALCIUM CHLORIDE
ALUMINUM SULFATE
ALUMINUM FLUORIDE
CALCIUM PHOSPHATE DIBASIC
BARIUM CARBONATE
MAGNESIUM SULFATE
MERCURY
NICKEL SULFATE
MISC ACYCLIC INSECTICIDES
METHYL BROMIDE
DIBROMOCHLOROPROPANE
MISC CYCLIC INSECTICIDES
DDT
MISC CYCLIC HERBICIDES
2,4-D ACID ESTORS + SALTS
DNBP
2,4-D ACID
2,4,5 T ACID
2,4,5-T ACID ESTORS + SALTS
HERBICIDES + PLANT HORMONES AC
FUNGICIDES TOTAL CYCLIC
MISC FUNGICIDES
MERCURY FUNGICIDE
2,4,5-TRICHLOROPHENOL + SALTS
FUNGICIDES ACYCLIC
FERBAM
NABAM
ETHERS TOTAL
ETHYL ETHERS ALL GRADES
ISOPROPYL ETHER
VINYL ACETATE
SODIUM METHYLATE
LAUROYL PEROXIDE
ETHYLENE OXIDE
CARBON DISULFIDE

TETRAETHYL LEAD
ETHYLENE
PROPYLENE OXIDE
PROPYLENE
GLYCERINE SYN + NAT
BUTANE
PROPANE
STYRENE
AMINES, TOTAL
PROPYLAMINES
MONOETHANOLAMINE
HEXAMETHYLENEDIAMINE
DIETHYLAMINE
HYPOCHLORITES
CHLORINE
BROMINE
OXYGEN
PHOSPHORIC ACID
HYDROCHLORIC ACID
HYDROGEN CYANIDE
FLUORINE HYDROFLUORIC ACID
CHROMIC ACID
BORIC ACID
SULFUR DIOXIDE
SULFUR
HYDROGEN PEROXIDE
PHOSPHORUS
HYDROGEN SULFIDE R
SULFURIC ACID
NITRIC ACID
UREA
AMMONIA CPDS
AMMONIA
AMMONIA SULFATE
AMMONIUM CHLORIDE
AMMONIUM NITRATE
LACTIC ACID
BENZOIC ACID
CHLORINATED ISOCYANURATES
MALEIC ANHYDRIDE
ADIPIC ACID
ACIDS ACYLHALIDES + ANHYDRIDES
TRICHLOROETHANE
TRICHLOROFLUOROMETHANE
CHLOROFORM
CHLOROMETHANE
DICHLORODIFLUOROMETHANE
PERCHLOROETHYLENE
TRICHLOROETHYLENE

HALOGENATED HYDROCARBONS
FORMALDEHYDE
ISOPROPYLACETONE
ALDAHYDES + KETONES
TRIMETHYLAMINE
TRIETHANOLAMINE
BUTYLAMINES
ETHANOLAMINES
PENTANE
ISOBUTANE
BUTENES
BUTADIENE INHIBITED
HEPTANE MIXED
PENTACHLOROPHENOL
PHENYL MERCURIC ACETATE
HERBICIDES + PLANT HORMONES CY
PARATHION
METHYL PARATHION
ALDRIN-TOXAPHENE GROUP
INSECTIDES RODENTICIDES CYCLIC
XYLENES
METHYLAMINES
PESTICIDES INSECTICIDES ACYCLI
LINDANE
ETHYLAMINES
FUMARIC ACID
ISOPRENE
ETHYLENE DICHLORIDE
EPICHLOROHYDRIN
ACETONITRILE
AMYL ALCOHOL
BUTYRIC ACID
CYCLOHEXYLAMINE
ETHYL FORMATE
FURFURYL ALCOHOL
GLYOXAL
HEXANE
ISOPENTANE
METHYL ACETATE
DODECYL MERCAPTAN
NITROPHENOL
NONENE
NITROANILINE
TETRAETHYLENE GLYCOL
TETRALIN
TURPENTINE
VINYL ETHER
ETHYLENIMINE
ZINC CHLORIDE

```
ZINC CPDS
ACRYLIC ACID
ACRYLONITRILE
TETRAMETHYL LEAD
BUTYL HYDROPEROXIDE
CALCIUM ARSENATE
SILVER NITRATE
SILVER CYANIDE
SODIUM DICHROMATE + CHROMATE
POTASSIUM PYROPHOSPHATE
DIOCTYL PHTHALATES
NAPTHALINE
XXXXXX

HAZARDOUS SUBSTANCES PRIORITY RANKING SYSTEM

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```
 ALL COMPOUNDS RANKED BY QI
             NAME                                          QI VALUE          RANK
SULFURIC ACID                                           5.75000+07             1
AMMONIA                                                 2.68000+07             2
OXYGEN                                                  2.60000+07             3
AMMONIA CPDS                                            2.30000+07             4
SODIUM HYDROXIDE                                        1.92000+07             5
SODIUM CARBONATE                                        1.33000+07             6
NITRIC ACID                                             1.25000+07             7
AMMONIUM NITRATE                                        1.12000+07             8
PHOSPHORIC ACID                                         9.80000+06             9
BENZENE                                                 8.50000+06            10
UREA                                                    6.37000+06            11
SODIUM CPDS                                             6.00000+06            12
ETHYLENE DICHLORIDE                                     5.80000+06            13
TOLUENE                                                 5.80000+06            14
HALOGENATED HYDROCARBONS                                5.79462+06            15
ACIDS ACYLHALIDES + ANHYDRIDES                          5.20960+06            16
AMMONIA SULFATE                                         5.20000+06            17
STYRENE                                                 4.85000+06            18
POTASSIUM CPDS                                          4.80000+06            19
ETHYL BENZENE                                           4.80000+06            20
METHYL ALCOHOL                                          4.60000+06            21
FORMALDEHYDE                                            4.35000+06            22
VINYL CHLORIDE                                          4.30000+06            23
HYDROCHLORIC ACID                                       4.06000+06            24
PROPANE                                                 3.90375+06            25
XYLENES                                                 3.90000+06            26
ALDAHYDES + KETONES                                     3.78061+06            27
```

ETHYLENE OXIDE	3.78000+06	28
POLYHYDRIC ALCOHOLS ESTERS + E	3.74349+06	29
ACETIC ACID, SYN.	3.60000+06	30
BUTADIENE INHIBITED	3.20000+06	31
SODIUM SULFATE	2.90000+06	32
CALCIUM CHLORIDE	2.70000+06	33
SODIUM PHOSPHATE	2.60000+06	34
SULFUR	2.40000+06	35
ALUMINUM SULFATE	2.40000+06	36
CALCIUM FLUORIDE	2.40000+06	37
ETHYLENE GLYCOL	2.40000+06	38
ETHYL ALCOHOL	2.40000+06	39
CALCIUM HYDROXIDE R	2.34200+06	40
CALCIUM CARBIDE	2.30000+06	41
ISOPROPYL ALCOHOL	2.10000+06	42
CYCLOHEXANE	2.00000+06	43
CHLORINE	1.96000+06	44
ACETIC ANHYDRIDE	1.70000+06	45
PHENOL	1.70000+06	46
ACETALDEHYDE	1.70000+06	47
ACETONE	1.62000+06	48
CUMENE	1.60000+06	49
BUTANE	1.38478+06	50
SODIUM SILICATE	1.30000+06	51
BUTENES	1.16108+06	52
ACRYLONITRILE	1.15096+06	53
PHOSPHORUS	1.10000+06	54
ESTERS OF MONOHYDRIC ALCOHOLS	9.88363+05	55
CARBON TETRACHLORIDE	9.70000+05	56
PROPYLENE	8.75000+05	57
VINYL ACETATE	8.25000+05	58
CARBON DISULFIDE	8.20000+05	59
CALCIUM PHOSPHATE DIBASIC	8.18000+05	60
PHTHALIC ANHYDRIDE	7.60000+05	61
NAPTHALINE	7.10000+05	62
FLUORINE HYDROFLUORIC ACID	7.00000+05	63
PERCHLOROETHYLENE	6.78685+05	64
HEXAMETHYLENEDIAMINE	6.49786+05	65
HYDROGEN SULFIDE R	6.40000+05	66
POTASSIUM SULFATE	6.00000+05	67
N-PROPYL ALCOHOL	5.82000+05	68
DODECYL BENZENE	5.80000+05	69
MAGNESIUM SULFATE	5.40000+05	70
TRICHLOROETHYLENE	5.27571+05	71
TETRAETHYL LEAD	5.00000+05	72
SODIUM SULFITE	5.00000+05	73
ETHERS TOTAL	4.91835+05	74
ACETONE CYANOHYDRIN	4.84928+05	75
SODIUM BORATE	4.60000+05	76

ISOPENTANE	4.53000+05	77
METHYL ETHYL KETONE	4.37842+05	78
DIOCTYL PHTHALATES	4.10000+05	79
METHYL METHACRYLATE	4.04586+05	80
ANILINE	3.85000+05	81
INSECTIDES RODENTICIDES CYCLIC	3.51755+05	82
SODIUM CHLORATE	3.40000+05	83
PROPYLENE GLYCOL	3.33000+05	84
BUTYL ALCOHOL N AND ISO	3.31248+05	85
GLYCERINE SYN + NAT	3.12000+05	86
SODIUM DICHROMATE + CHROMATE	3.04000+05	87
DICHLORODIFLUOROMETHANE	3.02159+05	88
ISOBUTANE	3.00286+05	89
HYDROGEN CYANIDE	3.00000+05	90
POTASSIUM HYDROXIDE	3.00000+05	91
TRICHLOROETHANE	2.88122+05	92
ETHANOLAMINES	2.72000+05	93
ALUMINUM FLUORIDE	2.63000+05	94
ETHYL CHLORIDE	2.58189+05	95
HERBICIDES + PLANT HORMONES CY	2.48892+05	96
AMINES, TOTAL	2.36026+05	97
FATTY ACIDS	2.35000+05	98
PERCHLORIC ACID	2.30000+05	99
CHLOROSULFONIC ACID	2.30000+05	100
FERROUS SULFATE	2.24000+05	101
MALEIC ANHYDRIDE	2.22000+05	102
DYES TOTAL	2.14661+05	103
BORIC ACID	2.14000+05	104
MISC CYCLIC HERBICIDES	2.10000+05	105
SODIUM METAL	2.00380+05	106
HEPTANE MIXED	1.95828+05	107
FURFURAL	1.90000+05	108
SULFUR DIOXIDE	1.81000+05	109
SODIUM SULFIDE	1.80000+05	110
ETHYLENE	1.75000+05	111
TURPENTINE	1.68000+05	112
ISOPROPYLACETONE	1.66852+05	113
TRICHLOROFLUOROMETHANE	1.55200+05	114
ETHYL ACETATE	1.46936+05	115
DIETHYLENE GLYCOL	1.43309+05	116
NONENE	1.43200+05	117
CHLOROBENZENE	1.42654+05	118
CHLOROFORM	1.39882+05	119
CHLOROMETHANE	1.39253+05	120
MISC CYCLIC INSECTICIDES	1.38755+05	121
PESTICIDES INSECTICIDES ACYCLI	1.37600+05	122
HEXANE	1.30300+05	123
PHOSPHORUS PENTASULFIDE	1.28000+05	124
BARIUM CARBONATE	1.26000+05	125

TETRAMETHYL LEAD	1.25000+05	126
ALDRIN-TOXAPHENE GROUP	1.20183+05	127
PROPYLENE OXIDE	1.20000+05	128
PHOSPHORUS TRICHLORIDE	1.20000+05	129
ISOPRENE	1.19000+05	130
DICHLOROBENZENE O,P.	1.15407+05	131
DINITRO ANILINE	1.11000+05	132
CITRIC ACID	1.10000+05	133
DDT	1.03411+05	134
AMMONIUM PERCHLORATE	1.00000+05	135
ZINC SULFATE	9.20000+04	136
HYDROGEN PEROXIDE	9.00000+04	137
POTASSIUM PYROPHOSPHATE	8.60000+04	138
COPPER SULFATE	8.40340+04	139
2,4-D ACID ESTORS + SALTS	8.37500+04	140
ETHYL ETHERS ALL GRADES	8.32870+04	141
FUNGICIDES TOTAL CYCLIC	8.08850+04	142
ISOOCTYL ALCOHOL	8.03810+04	143
HYPOCHLORITES	8.00000+04	144
NICKEL CPDS	8.00000+04	145
SODIUM HYDROSULFITE	8.00000+04	146
2,4-D ACID	7.71390+04	147
EPICHLOROHYDRIN	7.50240+04	148
ACETONITRILE	7.50000+04	149
CRESOLS TOTAL O,M,P.	7.35170+04	150
SORBITOL	7.13000+04	151
ADIPIC ACID	7.00000+04	152
METHYLAMINES	6.77420+04	153
N-BUTYL ACETATE	6.32960+04	154
MONOETHANOLAMINE	6.19850+04	155
BROMINE	6.00000+04	156
TRIETHANOLAMINE	5.96000+04	157
DIETHANOLAMINE	5.83050+04	158
ETHYL ACRYLATE	5.83040+04	159
TRIETHYLENE GLYCOL	5.76980+04	160
DECYL ALCOHOL	5.11530+04	161
AMMONIUM CHLORIDE	4.80000+04	162
PHOSPHOROUS OXYCHLORIDE	4.50000+04	163
CALCIUM HYPOCHLORITE	4.30000+04	164
ISOPROPYL ACETATE	4.20380+04	165
PROPYL ACETATE ISO-N	4.20380+04	166
CHROMIC ACID	4.20000+04	167
LEAD CPDS	4.20000+04	168
FUMARIC ACID	4.03600+04	169
NICKEL SULFATE	4.00000+04	170
ETHYLENEDIAMINE	4.00000+04	171
FUNGICIDES ACYCLIC	3.95280+04	172
MISC FUNGICIDES	3.90000+04	173
HERBICIDES + PLANT HORMONES AC	3.86900+04	174

BUTYL ACRYLATE	3.81580+04	175
ZINC CPDS	3.80000+04	176
ZINC CHLORIDE	3.80000+04	177
PENTACHLOROPHENOL	3.79590+04	178
CYCLOHEXYLAMINE	3.60000+04	179
METHYL PARATHION	3.33440+04	180
DIPROPYLENE GLYCOL	3.32490+04	181
AMYL ALCCHOL	3.22000+04	182
PROPYLENE DICHLORIDE	3.04000+04	183
ANTIMONY CPD	3.00000+04	184
2,4,5-T ACID ESTORS + SALTS	2.71890+04	185
DIBUTYL PHTHALATE	2.70920+04	186
NONYL PHENOL	2.64450+04	187
CHLORINATED ISOCYANURATES	2.60000+04	188
ETHYLAMINES	2.35830+04	189
FORMIC ACID	2.31420+04	190
OXALIC ACID	2.20000+04	191
2 ETHYLHEXYL ACRYLATE	2.05000+04	192
PROPRIONIC ACID	2.04440+04	193
CYCLOHEXANONE	2.03690+04	194
METHYL BROMIDE	1.96650+04	195
NITROPHENOL	1.89000+04	196
MORPHOLINE	1.76410+04	197
BENZYL CHLORIDE	1.65440+04	198
ACRYLIC ACID	1.64690+04	199
SODIUM ACETATE	1.57340+04	200
2,4,5-TRICHLOROPHENOL + SALTS	1.40000+04	201
NITROUS OXIDE	1.40000+04	202
SODIUM FLOURIDE	1.32000+04	203
TRIMETHYLAMINE	1.28000+04	204
MISC ACYCLIC INSECTICIDES	1.18835+04	205
PROPYLAMINES	1.15450+04	206
NITROBENZENE	1.14500+04	207
PARATHION	1.13610+04	208
2,4,5 T ACID	1.05520+04	209
DODECYL MERCAPTAN	1.02000+04	210
FURFURYL ALCOHOL	1.00000+04	211
METHYL ACETATE	8.80000+03	212
BENZOIC ACID	8.53700+03	213
BENZOYL PEROXIDE	8.53700+03	214
NITROANILINE	7.90000+03	215
PYRIDINE	7.55400+03	216
DIETHYLAMINE	7.04500+03	217
ISOPROPYL ETHER	6.10800+03	218
LINDANE	6.04200+03	219
LEAD ARSENATE	6.00000+03	220
ARSENIC CPDS	6.00000+03	221
LACTIC ACID	5.30000+03	222
HEXYL ALCOHOL	5.28000+03	223

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SODIUM METHYLATE                                   5.25300+03          224
DIBROMOCHLOROPROPANE                               5.24000+03          225
ETHYLENIMINE                                       5.00000+03          226
PENTANE                                            4.96000+03          227
ALCOHOLS, MONOHYDRIC, UNSUBSTI                     4.76600+03          228
DNBP                                               4.61900+03          229
CYCLOHEXYL ALCOHOL                                 4.33800+03          230
BENZALDEHYDE                                       3.93200+03          231
SILVER NITRATE                                     3.00000+03          232
BUTYLAMINES                                        3.00000+03          233
FERBAM                                             2.33100+03          234
POTASSIUM IODIDE                                   2.20000+03          235
DIVINYL BENZENE                                    2.19300+03          236
LAUROYL PEROXIDE                                   2.05000+03          237
TETRAETHYLENE GLYCOL                               1.70000+03          238
BERYLLIUM DUST                                     1.50000+03          239
CALCIUM ARSENATE                                   1.43000+03          240
NABAM                                              1.36100+03          241
BUTYL HYDROPEROXIDE                                1.30500+03          242
MERCURY FUNGICIDE                                  1.19600+03          243
ACETOPHENONE                                       1.19100+03          244
AMMONIUM ACETATE                                   8.45000+02          245
MERCURY CPDS                                       8.00000+02          246
GLYOXAL                                            6.53000+02          247
ZINC ACETATE                                       5.88000+02          248
BUTYRIC ACID                                       4.57000+02          249
MERCURY                                            4.28000+02          250
PHENYL MERCURIC ACETATE                            3.41000+02          251
MAGNESIUM CPDS                                     3.00000+02          252
ETHYL FORMATE                                      1.68000+02          253
SILVER CYANIDE                                     1.50000+02          254
CALCIUM NITRATE                                    1.16000+02          255
VINYL ETHER                                        1.12000+02          256
TETRALIN                                           4.30000+01          257

REJECTED SUBSTANCES
         NAME                                      Q VALUE            RANK
VINYL CHLORIDE                                     9.19067+05            1
CALCIUM HYDROXIDE R                                2.79777+05            2
PROPYLENE                                          1.87019+05            3
BUTANE                                             2.95978+05            4
PROPANE                                            8.34373+05            5
OXYGEN                                             2.01453+06            6
HYDROGEN SULFIDE R                                 6.73040+04            7
DICHLORODIFLUOROMETHANE                            6.45824+04            8
ISOBUTANE                                          6.41821+04            9
BUTENES                                            2.48165+05           10
BUTADIENE  INHIBITED                               6.83957+05           11
ISOPENTANE                                         9.68226+04           12
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VINYL ETHER                                   2.88005+01          13

INSOLUBLE WITH DENSITY LE 1
          NAME                                Q VALUE             RANK
CYCLOHEXANE                                   5.14294+05             1
CUMENE                                        4.11436+05             2
HEPTANE MIXED                                 4.18556+04             3
NONENE                                        3.06071+04             4
HEXANE                                        2.78499+04             5
DECYL ALCOHOL                                 9.61263+03             6
ETHYL ACRYLATE                                6.50052+03             7
BUTYL ACRYLATE                                4.25437+03             8
DIVINYL BENZENE                               5.63924+02             9

INSOLUBLE WITH DENSITY GT 1
          NAME                                Q VALUE             RANK
ETHYLENE DICHLORIDE                           1.23967+06             1
SULFUR                                        2.52390+05             2
PERCHLOROETHYLENE                             1.45060+05             3
TRICHLOROETHANE                               6.15822+04             4
DIOCTYL PHTHALATES                            4.57123+04             5
TRICHLOROFLUOROMETHANE                        3.31719+04             6
DINITRO ANILINE                               2.85433+04             7
EPICHLOROHYDRIN                               1.60354+04             8
BENZYL CHLORIDE                               4.25424+03             9
DIBUTYL PHTHALATE                             3.02058+03            10
METHYL BROMIDE                                2.24334+03            11
2,4,5-TRICHLOROPHENOL + SALTS                 1.59709+03            12
LAUROYL PEROXIDE                              4.38160+02            13
BERYLLIUM DUST                                1.71117+02            14
MERCURY                                       9.61840+01            15

SOLUBLE SUBSTANCES
          NAME                                Q/CRIT CONC         RANK
PHENOL                                        4.37150+08             1
METHYL ALCOHOL                                8.64428+07             2
INSECTIDES RODENTICIDES CYCLIC                4.01274+07             3
ACRYLONITRILE                                 2.46001+07             4
CHLOROSULFONIC ACID                           2.41874+07             5
BENZENE                                       2.18575+07             6
AMMONIA                                       1.66695+07             7
MISC CYCLIC INSECTICIDES                      1.58288+07             8
PHOSPHORUS PENTASULFIDE                       1.34608+07             9
STYRENE                                       1.03662+07            10
ACETONE CYANOHYDRIN                           1.03647+07            11
CHLORINE                                      8.54443+06            12
NONYL PHENOL                                  6.80026+06            13
DDT                                           5.89844+06            14
ISOPRENE                                      5.08693+06            15
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XYLENES	5.01437+06	16
NITROPHENOL	4.86008+06	17
ALDRIN-TOXAPHENE GROUP	4.57007+06	18
AMMONIUM NITRATE	4.17982+06	19
ALUMINUM SULFATE	3.94075+06	20
NITRIC ACID	3.26269+06	21
HERBICIDES + PLANT HORMONES CY	2.83930+06	22
DYES TOTAL	2.75997+06	23
TETRAETHYL LEAD	2.13736+06	24
AMMONIA SULFATE	1.94063+06	25
FUNGICIDES TOTAL CYCLIC	1.84543+06	26
SULFURIC ACID	1.50084+06	27
HALOGENATED HYDROCARBONS	1.23852+06	28
PHOSPHORUS	1.15679+06	29
2,4-D ACID ESTORS + SALTS	9.55401+05	30
BENZOIC ACID	9.51820+05	31
FORMALDEHYDE	9.29754+05	32
2,4-D ACID	8.79984+05	33
SODIUM DICHROMATE + CHROMATE	7.95155+05	34
PESTICIDES INSECTICIDES ACYCLI	7.84854+05	35
TETRAMETHYL LEAD	5.34341+05	36
ETHERS TOTAL	5.25615+05	37
FERROUS SULFATE	5.03393+05	38
SODIUM SULFIDE	4.70815+05	39
HYDROCHLORIC ACID	4.26959+05	40
NICKEL CPDS	3.59567+05	41
BENZALDEHYDE	3.37034+05	42
HYDROGEN CYANIDE	3.15487+05	43
BUTYL ALCOHOL N AND ISO	3.11239+05	44
CHLORINATED ISOCYANURATES	2.89883+05	45
CALCIUM FLUORIDE	2.86706+05	46
HEXAMETHYLENEDIAMINE	2.77766+05	47
FATTY ACIDS	2.62010+05	48
PYRIDINE	1.94249+05	49
LEAD CPDS	1.88772+05	50
NAPTHALINE	1.82575+05	51
CARBON DISULFIDE	1.75264+05	52
HYPOCHLORITES	1.74376+05	53
CALCIUM HYPOCHLORITE	1.71227+05	54
COPPER SULFATE	1.25899+05	55
SODIUM HYDROXIDE	1.25551+05	56
ACIDS ACYLHALIDES + ANHYDRIDES	1.16167+05	57
DODECYL MERCAPTAN	1.09006+05	58
PHOSPHORIC ACID	1.03059+05	59
NITROBENZENE	9.81445+04	60
METHYL PARATHION	9.50952+04	61
ALCOHOLS, MONOHYDRIC, UNSUBSTI	8.95623+04	62
CHROMIC ACID	8.83364+04	63
ALDAHYDES + KETONES	6.08054+04	64

MISC CYCLIC HERBICIDES	7.98544+04	65
FLUORINE HYDROFLUORIC ACID	7.36137+04	66
MISC ACYCLIC INSECTICIDES	6.77821+04	67
POTASSIUM IODIDE	5.75441+04	68
SODIUM CARBONATE	5.11589+04	69
AMINES, TOTAL	5.04474+04	70
ANILINE	4.95008+04	71
ALUMINUM FLUORIDE	4.31841+04	72
AMMONIA CPDS	4.29177+04	73
CARBON TETRACHLORIDE	4.14649+04	74
FURFURAL	4.07150+04	75
LINDANE	3.82921+04	76
SULFUR DIOXIDE	3.80688+04	77
AMMONIUM PERCHLORATE	3.73198+04	78
MERCURY CPDS	3.59567+04	79
ACETONITRILE	3.20605+04	80
TOLUENE	2.98291+04	81
TRIMETHYLAMINE	2.73583+04	82
MERCURY FUNGICIDE	2.72874+04	83
LEAD ARSENATE	2.69675+04	84
ETHYL BENZENE	2.46861+04	85
PERCHLORIC ACID	2.41874+04	86
METHYLAMINES	2.22753+04	87
PENTACHLOROPHENOL	2.16514+04	88
SODIUM HYDROSULFITE	2.09251+04	89
ACETALDEHYDE	1.81676+04	90
AMMONIUM CHLORIDE	1.79135+04	91
ETHYLENEDIAMINE	1.70989+04	92
ACETIC ACID, SYN.	1.60551+04	93
CALCIUM CARBIDE	1.52644+04	94
BARIUM CARBONATE	1.50521+04	95
CYCLOHEXYLAMINE	1.40720+04	96
SILVER NITRATE	1.34837+04	97
ARSENIC CPDS	9.29784+03	98
ETHYL ALCOHOL	9.02012+03	99
ACETONE	8.65633+03	100
ZINC CPDS	8.53971+03	101
ZINC CHLORIDE	8.53971+03	102
ETHYLENE OXIDE	8.07924+03	103
SODIUM CPDS	7.84692+03	104
PHTHALIC ANHYDRIDE	7.81728+03	105
PHENYL MERCURIC ACETATE	7.78010+03	106
ACETIC ANHYDRIDE	7.58156+03	107
POLYHYDRIC ALCOHOLS ESTERS + E	7.03474+03	108
ZINC SULFATE	6.89169+03	109
MISC FUNGICIDES	6.35576+03	110
POTASSIUM CPDS	6.27754+03	111
VINYL ACETATE	5.87775+03	112
N-PROPYL ALCOHOL	5.46645+03	113

ETHYLAMINES	5.04055+03	114
FUNGICIDES ACYCLIC	4.50926+03	115
POTASSIUM HYDROXIDE	3.92346+03	116
METHYL ETHYL KETONE	3.74331+03	117
NITROUS OXIDE	3.65421+03	118
SILVER CYANIDE	3.37094+03	119
PARATHION	3.24009+03	120
CHLOROFORM	2.98979+03	121
CHLOROMETHANE	2.97634+03	122
DICHLOROBENZENE O,P.	2.96766+03	123
PHOSPHORUS TRICHLORIDE	2.52390+03	124
CALCIUM CHLORIDE	2.15029+03	125
2,4,5-T ACID ESTORS + SALTS	2.06777+03	126
TRICHLOROETHYLENE	2.05020+03	127
ESTERS OF MONOHYDRIC ALCOHOLS	1.85732+03	128
ACRYLIC ACID	1.83619+03	129
ACETOPHENONE	1.80154+03	130
NICKEL SULFATE	1.79783+03	131
CALCIUM ARSENATE	1.70829+03	132
ETHYLENE	1.70018+03	133
SODIUM PHOSPHATE	1.70017+03	134
METHYL METHACRYLATE	1.50362+03	135
DODECYL BENZENE	1.49145+03	136
SODIUM METAL	1.31031+03	137
BUTYLAMINES	1.28242+03	138
SODIUM SULFATE	1.26423+03	139
SODIUM FLUORIDE	1.15088+03	140
CHLOROBENZENE	1.04809+03	141
PHOSPHOROUS OXYCHLORIDE	9.46462+02	142
2,4,5 T ACID	8.02498+02	143
ETHANOLAMINES	7.26704+02	144
MALEIC ANHYDRIDE	7.07187+02	145
SODIUM SULFITE	6.53910+02	146
TRIETHANOLAMINE	6.36935+02	147
CYCLOHEXANONE	4.76167+02	148
HERBICIDES + PLANT HORMONES AC	4.41367+02	149
ISOPROPYL ALCOHOL	4.38478+02	150
TURPENTINE	4.32007+02	151
BROMINE	3.92346+02	152
NABAM	3.10519+02	153
SODIUM BORATE	3.00799+02	154
FERBAM	2.65915+02	155
DNBP	2.63462+02	156
CALCIUM PHOSPHATE DIBASIC	2.44297+02	157
HYDROGEN PEROXIDE	2.36615+02	158
SODIUM CHLORATE	2.22329+02	159
MONOETHANOLAMINE	1.89264+02	160
AMMONIUM ACETATE	1.88424+02	161
ANTIMONY CPD	1.68547+02	162

MAGNESIUM SULFATE	1.61272+02	163
ISOOCTYL ALCOHOL	1.51051+02	164
DIETHANOLAMINE	1.24619+02	165
PROPYLAMINES	1.23379+02	166
N-BUTYL ACETATE	1.18945+02	167
POTASSIUM SULFATE	8.71880+01	168
NITROANILINE	8.46443+01	169
PROPYL ACETATE ISO-N	7.89975+01	170
UREA	7.42897+01	171
SODIUM SILICATE	7.08403+01	172
PROPYLENE DICHLORIDE	6.49759+01	173
PROPYLENE GLYCOL	6.25771+01	174
ETHYL CHLORIDE	5.51844+01	175
BENZOYL PEROXIDE	5.48816+01	176
ETHYLENE GLYCOL	4.51006+01	177
ETHYLENIMINE	3.56227+01	178
ETHYL ACETATE	2.76121+01	179
PROPYLENE OXIDE	2.56484+01	180
OXALIC ACID	2.45286+01	181
PROPRIONIC ACID	2.27937+01	182
SODIUM METHYLATE	2.23948+01	183
AMYL ALCOHOL	2.01700+01	184
FURFURYL ALCOHOL	1.87919+01	185
DIETHYLENE GLYCOL	1.79537+01	186
ETHYL ETHERS ALL GRADES	1.78015+01	187
DIETHYLAMINE	1.50577+01	188
POTASSIUM PYROPHOSPHATE	1.49963+01	189
CITRIC ACID	1.36270+01	190
SORBITOL	1.33986+01	191
ZINC ACETATE	1.31116+01	192
SODIUM ACETATE	1.25303+01	193
BORIC ACID	1.12524+01	194
CYCLOHEXYL ALCOHOL	1.11550+01	195
TETRALIN	1.10573+01	196
TRIETHYLENE GLYCOL	1.08426+01	197
PENTANE	1.06013+01	198
HEXYL ALCOHOL	9.92213+00	199
ADIPIC ACID	9.75568+00	200
FUMARIC ACID	8.99975+00	201
DIBROMOCHLOROPPOPANE	7.65368+00	202
BUTYL HYDROPEROXIDE	6.97315+00	203
GLYCERINE SYN + NAT	6.66658+00	204
DIPROPYLENE GLYCOL	6.24812+00	205
METHYL ACETATE	4.90571+00	206
MORPHOLINE	4.53633+00	207
CRESOLS TOTAL O,M,P.	3.78094+00	208
ETHYL FORMATE	3.74618+00	209
ISOPROPYLACETONE	3.57685+00	210
2 ETHYLHEXYL ACRYLATE	2.26562+00	211

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ISOPROPYL ETHER                          1.30550+00      212
LACTIC ACID                              9.16148-01      213
ISOPROPYL ACETATE                        7.89975-01      214
FORMIC ACID                              5.48975-01      215
BUTYRIC ACID                             5.09525-01      216
MAGNESIUM CPDS                           3.58382-01      217
TETRAETHYLENE GLYCOL                     3.19463-01      218
CALCIUM NITRATE                          3.46436-02      219
GLYOXAL                                  1.22711-02      220

 COMPOUNDS WHERE P EQUALS 2
  NAME OF COMPOUND
CALCIUM HYDROXIDE R
HYDROGEN SULFIDE R
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 INITIAL DATA

REJECTED SUBSTANCES
VINYL CHLORIDE
        4.780000+01    4.030000+01    1.190000+01    1.000000+02    9.100000-01    4.300000+00    1.000000+03
   1  -14     0
FISH      0
        0.000000       0.000000       9.010000+02    9.010000+02    0.000000       0.000000
CALCIUM HYDROXIDE K
        7.000000-01    8.360000+01    1.570000+01    1.800000+01    2.240000+00    2.342000+06    1.850000+03
   2 9999      2
FISH      0
        2.000000-01    1.000000-01    9.010000+02    4.000000+02    9.000000+04    9.000000+04
PROPYLENE
        4.780000+01    4.030000+01    1.190000+01    1.000000+03    2.000000-03    8.750000+05    8.800000+02
   3  -47     0
FISH      0
        0.000000       0.000000       9.020000+02    9.020000+02    0.000000       0.000000
BUTANE
        4.780000+01    4.030000+01    1.190000+01    1.000000+03    6.000000-01    1.384780+06    1.000000+03
   4  -1      0
FISH      0
        0.000000       0.000000       9.010000+02    9.010000+02    0.000000       0.000000
PROPANE
        4.780000+01    4.030000+01    1.190000+01    1.000000+03    1.000000-03    3.903746+06    1.300000+02
   5  -44     0
FISH      0
        0.000000       0.000000       9.010000+02    9.010000+02    0.000000       0.000000
OXYGEN
        4.000000+00    8.900000+01    6.500000+00    1.000000+02    1.000000-03    2.000000+07    6.000000+00
   6 -182     0
DOME      0
        0.000000       0.000000       9.010000+02    9.010000+02    0.000000       0.000000
HYDROGEN SULFIDE K
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        1.100000+00    8.570000+01    1.290000+01    5.000000-02    1.000000-02    6.400000+05    5.000000+04
   7  -20    2
TAST     0
        5.000000-02    5.000000-02    1.070000+02    1.070000+02    1.004290+05    1.004290+05
DICHLORODIFLUOROMETHANE
        4.780000+01    4.030000+01    1.190000+01    1.000000+02    1.400000+00    3.021590+05    1.000000-02
   8  -28    0
FISH     0
        0.000000       0.000000       9.010000+02    9.010000+02    0.000000       0.000000
ISOBUTANE
        4.780000+01    4.030000+01    1.190000+01    1.000000+02    1.100000+00    3.002860+05    1.000000-02
   9   11    0
FISH     0
        0.000000       0.000000       9.010000+02    9.010000+02    0.000000       0.000000
BUTENES
        4.780000+01    4.030000+01    1.190000+01    1.000000+02    1.100000+00    1.161079+06    1.000000-02
  10   30    0
FISH     0
        0.000000       0.000000       9.010000+02    9.010000+02    0.000000       0.000000
BUTADIENE  INHIBITED
        4.780000+01    4.030000+01    1.190000+01    7.200000+01    1.000000-03    3.200000+06    2.000000+00
  11   -1    0
FISH     0
        0.000000       0.000000       9.010000+02    9.010000+02    0.000000       0.000000
ISOPENTANE
        4.780000+01    4.030000+01    1.190000+01    1.000000+02    6.000000-01    4.530000+05    1.000000+01
  12   30    0
FISH     0
        1.000000+01    1.000000-03    5.010000+02    5.000000+02    9.000000+04    2.801000+03
VINYL ETHER
        7.960000+01    1.480000+01    5.600000+00    1.000000+01    7.800000-01    1.120000+02    1.000000+00
  13   39    0
FISH     0
        1.000000+03    1.000000+01    0.000000       5.000000+02    0.000000       4.101005+06

INSOLUBLE WITH DENSITY LE 1
CYCLOHEXANE
        7.960000+01    1.480000+01    5.600000+00    1.000000+01    7.700000-01    2.000000+06    1.000000-02
   1   81    1
FISH     HZ
        0.000000       0.000000       9.020000+02    9.020000+02    0.000000       0.000000
CUMENE
        7.960000+01    1.460000+01    5.600000+00    1.000000+02    8.600000-01    1.600000+06    1.000000-02
   2  152    1
FISH     HZ
        0.000000       0.000000       9.020000+02    9.020000+02    0.000000       0.000000
HEPTANE MIXED
        4.780000+01    4.030000+01    1.190000+01    1.000000+02    6.800000-01    1.958280+05    5.200000+01
   3   98    1
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FISH      G
        0.000000     0.000000     9.020000+02  9.020000+02  0.000000     0.000000
NONENE
        4.780000+01  4.030000+01  1.190000+01  1.000000+02  7.000000-01  1.432000+05  1.000000+00
   4  140    1
FISH      HZ
        2.000000+01  1.000000-03  5.010000+02  5.000000+02  9.000000+04  2.601000+05
HEXANE
        4.790000+01  4.030000+01  1.190000+01  1.000000+03  6.600000-01  1.303000+05  1.300000+02
   5   69    1
FISH      HZ
        1.000000+01  1.000000-03  5.010000+02  5.000000+02  9.000000+04  2.601000+05
DECYL ALCOHOL
        6.600000+00  6.620000+01  2.480000+01  1.000000+04  6.200000-01  5.115500+04  1.000000-01
   6  231    1
FISH      HZ
        0.000000     0.000000     9.020000+02  9.020000+02  0.000000     0.000000
ETHYL ACRYLATE
        1.000000-01  8.540000+01  1.450000+01  1.000000+02  9.200000-01  5.630400+04  1.000000+02
   7   96    1
FISH      ANNFG
        1.500000+01  1.000000+01  1.230000+02  5.000000+02  2.107000+04  4.101005+06
BUTYL ACRYLATE
        1.000000-01  8.540000+01  1.450000+01  1.000000+03  8.900000-01  3.615800+04  1.000000-01
   8  145    1
FISH      HZ
        1.500000+01  1.000000+01  1.230000+02  5.000000+02  2.107000+04  4.101005+06
DIVINYL BENZENE
        7.960000+01  1.480000+01  5.600000+00  1.000000+01  9.300000-01  2.193000+03  1.000000-02
   9  199    1
FISH      HZ
        0.000000     0.000000     9.020000+02  9.020000+02  0.000000     0.000000

INSOLUBLE WITH DENSITY GT 1
ETHYLENE DICHLORIDE
        4.780000+01  4.030000+01  1.190000+01  1.000000+02  1.100000+00  5.600000+06  1.000000-02
   1   40    1
FISH      G
        0.000000     0.000000     9.030000+02  9.030000+02  0.000000     0.000000
SULFUR
        1.100000+00  8.570000+01  1.290000+01  1.000000-01  1.800000+00  2.400000+06  1.000000-03
   2  444    1
TAST      G
        1.000000+00  1.000000+00  1.360000+02  1.360000+02  4.207100+04  4.207100+04
PERCHLOROETHYLENE
        4.780000+01  4.030000+01  1.190000+01  1.600000+02  1.600000+00  6.786850+05  1.000000-02
   3  121    1
FISH      G
        0.000000     0.000000     9.030000+02  9.030000+02  0.000000     0.000000
```

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TRICHLOROETHANE
          4.780000+01   4.030000+01   1.190000+01   7.500000+01   1.300000+00   2.881220+05   1.000000+00
  4   74    1
FISH      ABFG
          1.000000+01   1.000000-01   5.010000+02   5.000000+02   9.000000+04   2.604760+05
DIOCTYL PHTHALATES
          1.000000-01   8.540000+01   1.450000+01   2.000000+02   1.200000+00   4.100000+05   1.000000+01
  5  280    1
TAST      G
          1.500000+01   1.000000+01   1.230000+02   5.000000+02   2.107000+04   4.101000+04
TRICHLOROFLUOROMETHANE
          4.780000+01   4.030000+01   1.190000+01   2.000000+02   1.400000+00   1.552000+05   1.000000-02
  6   40    1
FISH      G
          0.000000      0.000000      9.030000+02   9.030000+02   0.000000      0.000000
DINITRO ANILINE
          7.960000+01   1.480000+01   5.600000+00   1.000000+02   1.600000+00   1.110000+05   1.000000-02
  799999    1
FISH      G
          7.000000+00   1.200000-02   1.210000+02   1.210000+02   4.202000+05   2.503830+05
EPICHLOROHYDRIN
          4.760000+01   4.030000+01   1.190000+01   1.000000+02   1.200000+00   7.502400+04   1.000000-02
  8  117    1
FISH      G
          0.000000      0.000000      9.030000+02   9.030000+02   0.000000      0.000000
BENZYL CHLORIDE
          7.960000+01   1.480000+01   5.600000+00   1.000000+01   1.100000+00   1.654400+04   1.000000-02
  9  179    1
FISH      G
          0.000000      0.000000      9.030000+02   9.030000+02   0.000000      0.000000
DIBUTYL PHTHALATE
          1.000000-01   8.540000+01   1.450000+01   1.000000+03   1.400000+00   2.709200+04   4.000000+02
 10  340    1
TAST      ABFG
          1.500000+01   1.000000+01   1.230000+02   5.000000+02   2.107000+04   4.101005+06
METHYL BROMILE
          7.200000+00   8.070000+01   1.180000+01   1.000000+03   1.700000+00   1.966500+04   9.000000+02
 11    4    1
FISH      G
          0.000000      0.000000      9.030000+02   9.030000+02   0.000000      0.000000
2,4,5-TRICHLOROPHENOL + SALTS
          7.200000+00   8.070000+01   1.180000+01   1.000000+00   1.100000+00   1.400000+04   1.000000-02
 1299999    1
FISH      ABFG
          1.000000-01   1.000000-01   1.240000+02   1.240000+02   1.003030+05   1.003030+05
LAUROYL PEROXIDE
          4.780000+01   4.030000+01   1.190000+01   4.000000+01   2.000000+00   2.050000+03   1.000000-01
 1399999    1
DOME      G
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          1.000000-01    1.000000-02    1.380000+02    5.000000+02    4.003260+05    9.000000+04
BERYLLIUM DUST
          7.200000+00    5.070000+01    1.180000+01    1.500000+01    2.000000+00    1.500000+03    1.000000-02
 1499999     1
CROP        6
          1.000000-01    2.000000-02    9.000000+00    4.000000+02    1.101160+05    9.000000+04
MERCURY
          2.000000+00    6.060000+01    3.470000+01    5.000000-03    1.354000+01    4.280000+02    5.000000-04
  15   350     1
DOME        0
          0.000000       0.000000       9.030000+02    9.030000+02    0.000000       0.000000
SOLUBLE SUBSTANCES
PHENOL
          7.960000+01    1.480000+01    5.600000+00    1.000000-03    1.070000+00    1.700000+06    6.700000+04
   1   182     1
TAST        ABFG
          1.000000-03    1.000000-03    1.240000+02    5.000000+02    3.201900+04    3.104250+05
METHYL ALCOHOL
          8.600000+00    6.620000+01    2.480000+01    1.000000-02    7.900000-01    4.600000+06    5.000000+04
   2    64     1
DONE        ABFGI
          3.500000+00    5.000000-04    1.320000+02    5.000000+02    4.202440+05    1.802430+05
INSECTIDES RODENTICIDES CYCLIC
          7.200000+00    8.070000+01    1.180000+01    1.000000-03    8.000000-01    3.517550+05    1.000000-02
  399999     1
FISH        ABFG
          1.000000+03    1.000000-03    0.000000       5.000000+02    0.000000       9.000000+04
ACRYLONITRILE
          4.780000+01    4.030000+01    1.190000+01    1.000000-02    8.000000-01    1.150957+06    5.000000+03
   4    78     1
DOME        ABCEFGIZ
          1.000000+01    1.000000-03    1.250000+02    5.000000+02    4.201710+05    9.000000+04
CHLOROSULFONIC ACID
          1.100000+00    3.570000+01    1.290000+01    1.000000-03    1.800000+00    2.300000+05    1.000000+03
   5   158     1
H2S         ABCIZ
          5.000000-02    5.000000-02    1.070000+02    1.070000+02    1.004290+05    1.004290+05
BENZENE
          7.960000+01    1.480000+01    5.600000+00    1.000000-01    8.790000-01    8.500000+06    8.200000+02
   6    80     1
TAST        ABHFG
          1.000000+01    1.000000-03    1.370000+02    5.000000+02    4.501350+05    2.601000+03
AMMONIA
          4.470000+01    4.790000+01    9.200000+00    3.000000-01    7.000000-03    2.080000+07    5.000000+04
   7   -33     1
TAST        ABC
          2.000000-01    1.000000-02    3.000000+00    3.000000+00    1.001930+05    1.001930+05
MISC CYCLIC INSECTICIDES
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          7.200000+00   8.070000+01   1.180000+01   1.000000-03   8.000000-01   1.387550+05   1.000000-02
   899999    1
FISH       ABFG
          1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      3.901023+06
PHOSPHORUS PENTASULFIDE
          1.100000+00   8.570000+01   1.290000+01   1.000000-03   2.020000+00   1.280000+05   2.030000+02
   9  514    1
H2S        ABCI
          5.000000-02   5.000000-02   1.070000+02   1.070000+02   1.004290+05   1.004290+05
STYRENE
          4.780000+01   4.030000+01   1.190000+01   1.000000-01   9.000000-01   4.850000+06   1.000000+03
  10  146    1
TAST       ABHFG
          1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      2.801000+03
ACETONE CYANOHYDRIN
          4.780000+01   4.030000+01   1.190000+01   1.000000-02   9.320000-01   4.849280+05   1.000000+03
  11  120    1
DOME       ABCEFG
          3.000000-02   3.000000-02   1.170000+02   1.170000+02   1.004800+04   1.004800+04
CHLORINE
          9.600000+00   7.640000+01   1.370000+01   3.000000-02   3.200000+00   1.960000+06   5.000000+04
  12  -35    1
FISH       ABFGCI
          1.000000-01   1.000000-02   1.050000+02   1.050000+02   1.003600+05   1.003810+05
NONYL PHENOL
          7.960000+01   1.480000+01   5.600000+00   1.000000-03   9.400000-01   2.644500+04   1.000000+01
  13  300    1
TAST       ABHFG
          1.000000-01   1.000000-03   1.240000+02   5.000000+02   1.003030+05   3.104250+05
DDT
          7.200000+00   8.070000+01   1.180000+01   2.000000-03   9.800000-01   1.034110+05   1.000000-02
  14  200    1
FISH       ABFG
          1.000000-03   1.000000-06   6.000000+02   5.000000+02   1.401200+04   1.507300+04
ISOPRENE
          4.780000+01   4.030000+01   1.190000+01   5.000000-03   7.800000-01   1.190000+05   1.000000-02
  15   34    1
TAST       ABHF
          1.000000+01   1.000000-03   5.010000+02   5.000000+02   9.000000+04   2.801000+03
XYLENES
          7.960000+01   1.480000+01   5.600000+00   2.000000-01   8.600000-01   3.900000+06   1.000000+01
  16  139    1
TAST       ABHFG
          1.000000+01   1.000000-03   8.000000+02   5.000000+02   4.301600+04   2.801000+03
NITROPHENOL
          7.960000+01   1.480000+01   5.600000+00   1.000000-03   1.400000+00   1.890000+04   1.600000+04
  17  200    1
TAST       ABFG
          1.000000-03   1.000000-03   1.240000+02   5.000000+02   3.305800+04   3.105800+04
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ALDRIN-TOXAPHENE GROUP
          7.200000+00   8.070000+01   1.180000+01   3.000000-03   8.000000-01   1.201830+05   1.000000-02
  1899999    1
FISH      ALFG
          5.000000-01   1.000000-06   1.340000+02   5.000000+02   4.307500+04   1.401200+04
AMMONIUM NITRATE
          4.270000+01   4.790000+01   9.200000+00   5.000000-01   2.000000+00   1.120000+07   5.000000+04
  1999999    1
TAST      ALG
          2.000000-01   1.000000-02   3.000000+00   3.000000+00   1.001930+05   1.001930+05
ALUMINUM SULFATE
          4.600000+01   3.010000+01   3.300000+00   1.000000-01   2.710000+00   2.400000+06   3.100000+05
  2099999    1
TAST      ALCZ
          2.000000-02   2.000000-02   2.000000+00   2.000000+00   1.005300+04   1.005300+04
NITRIC ACID
          4.010000+01   3.230000+01   2.140000+01   1.000000+00   1.500000+00   1.250000+07   5.000000+04
  21   80    1
FISH      ALCI2
          4.000000-01   1.000000-02   3.010000+02   1.120000+02   9.000000+04   1.001950+05
HERBICIDES + PLANT HORMONES CY
          7.200000+00   8.070000+01   1.160000+01   1.000000-02   9.000000-01   2.488920+05   1.000000+02
  2299999    1
TAST      ALFG
          1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
DYES   TOTAL
          7.960000+01   1.461000+01   5.600000+00   2.000000-02   1.000000+00   2.146610+05   5.000000+04
  2399999    1
COLO      ALFG
          1.000000-02   1.000000-02   1.300000+02   1.300000+02   9.000000+04   9.000000+04
TETRAETHYL LEAD
          4.780000+01   4.030000+01   1.190000+01   5.000000-02   1.600000+00   5.000000+05   6.000000-02
  24  200    1
DOME      ALFG
          5.000000-02   5.000000-02   1.080000+02   1.760000+02   1.001630+05   1.001630+05
AMMONIA SULFATE
          4.270000+01   4.790000+01   9.200000+00   5.000000-01   1.770000+00   5.200000+06   7.100000+05
  2599999    1
TAST      ALG
          2.000000-01   1.000000-02   3.000000+00   3.000000+00   1.001930+05   1.001930+05
FUNGICIDES TOTAL CYCLIC
          7.200000+00   8.070000+01   1.180000+01   5.000000-03   9.000000-01   6.088500+04   1.000000-02
  2699999    1
FISH      ALFG
          1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
SULFURIC ACID
          4.010000+01   3.230000+01   2.140000+01   1.000000+01   1.800000+00   5.750000+07   5.000000+04
  27  330    1
FISH      ALCI2
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          1.000000+00   1.000000+00   3.010000+02   3.010000+02   9.000000+04   9.000000+04
HALOGENATED HYDROCARBONS
          4.780000+01   4.030000+01   1.190000+01   1.000000+00   1.100000+00   5.794615+06   5.000000+04
  2899999    1
TAST      ABHFG
          1.000000+03   1.000000-02   0.000000      5.000000+02   0.000000      2.604760+05
PHOSPHORUS
          1.100000+00   6.570000+01   1.290000+01   1.000000-01   1.800000+00   1.100000+06   3.000000+00
  29  280    1
FISH      ABCZ
          1.000000+00   2.000000-02   1.130000+02   1.130800+02   9.000000+04   1.002300+05
2,4-D ACID ESTONS + SALTS
          7.200000+00   8.070000+01   1.180000+01   1.000000-02   9.000000-01   8.375000+04   3.500000+04
  3099999    1
TAST      ABHFG
          2.000000+00   1.000000-02   6.000000+02   5.000000+02   1.208270+05   1.308900+04
BENZOIC ACID
          1.600000-01   8.540000+01   1.450000+01   1.000000-03   1.320000+00   8.537000+03   1.000000+02
  31  249    1
TAST      ABCIZ
          1.000000+01   6.000000-01   1.250000+02   5.000000+02   4.201710+05   1.607970+05
FORMALDEHYDE
          4.780000+01   4.030000+01   1.190000+01   1.000000+00   8.150000-01   4.350000+06   5.000000+04
  32  -21    1
TAST      ABFG
          1.000000-02   1.000000-01   1.200000+02   1.200000+02   3.803440+05   1.901430+05
2,4-D ACID
          7.200000+00   8.070000+01   1.180000+01   1.000000-02   9.000000-01   7.713900+04   1.000000+02
  3399999    1
TAST      ABFG
          2.000000+00   1.000000-02   6.000000+02   5.000000+02   1.208270+05   1.304900+05
SODIUM DICHROMATE + CHROMATE
          9.600000+00   7.640000+01   1.370000+01   5.000000-02   3.000000+00   3.040000+05   8.730000+05
  3499999    1
DONE      ABCEGZ
          3.000000-03   3.000000-03   1.060000+02   1.060000+02   1.001200+04   1.001200+04
PESTICIDES INSECTICIDES ACYCLI
          7.200000+00   8.070000+01   1.180000+01   2.000000-02   8.000000-01   1.376000+05   5.000000+04
  3599999    1
FISH      ABFG
          1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
TETRAMETHYL LEAD
          4.780000+01   4.030000+01   1.190000+01   5.090000-02   1.900000+00   1.250000+05   6.000000-02
  36  160    1
DONE      ABFG
          5.000000-02   5.000000-02   1.080000+02   1.080000+02   1.001630+05   1.001630+05
ETHERS TOTAL
          4.780000+01   4.030000+01   1.190000+01   2.000000-01   9.000000-01   4.918350+05   5.000000+04
  37   40    1
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DUHE      AUFG
          1.000000+03   1.000000+01   0.000000      5.000000+02   0.000000      4.101005+06
FERROUS SULFATE
          2.000000+03   [illegible].000000+01   3.470000+01   1.000000-01   3.100000+00   2.240000+05   1.000000+03
  3899999    1
TAST      AUCZ
          2.000000-02   2.000000-02   5.000000+00   5.000000+00   1.005600+04   1.005600+04
SODIUM SULFIDE
          9.800000+06   7.640000+01   1.770000+01   5.000000-02   1.800000+00   1.800000+05   1.540000+05
  3999999    1
TAST      AUCI
          5.000000-02   5.000000-02   1.070000+02   1.070000+02   1.004290+05   1.004290+05
HYDROCHLORIC ACID
          1.100000+00   8.570000+01   1.290000+01   1.000000+00   1.630000+00   4.060000+06   5.000000+04
  40  -84    1
TAST      AUCIZ
          4.000000-01   4.000000-01   3.010000+02   3.010000+02   9.000000+04   9.000000+04
NICKEL CPDS
          2.000000+00   6.060000+01   3.470000+01   5.000000-02   3.000000+00   8.000000+04   6.420000+05
  41  400    1
DUHE      ALCGZ
          2.500000+00   2.500000+00   1.110000+02   1.110000+02   5.005100+05   5.005100+05
BENZALDEHYDE
          7.960000+01   1.480000+01   5.600000+00   3.000000-03   1.040000+00   3.932000+03   1.000000+03
  42  178    1
TAST      AUF6
          1.000000-02   1.000000+01   1.200000+02   5.000000+02   3.803440+05   4.101005+06
HYDROGEN CYANIDE
          1.100000+00   6.570000+01   1.290000+01   1.000000-01   6.870000-01   3.000000+05   5.000000+04
  43   26    1
FISH      AUFG
          3.000000-02   3.000000-02   1.170000+02   1.170000+02   1.004800+04   1.004800+04
BUTYL ALCOHOL N AND ISO
          6.000000+00   6.620000+01   2.480000+01   2.000000-01   8.000000-01   3.312480+05   1.250000+05
  44  100    1
TAST      AUFGI
          5.000000+00   5.000000-04   1.320000+02   5.000000+02   4.307600+04   1.802430+05
CHLORINATED ISOCYANURATES
          1.000000-01   5.540000+01   1.450000+01   1.000000-02   1.200000+00   2.600000+04   1.000000+04
  45  200    1
DUHE      AUFGCIZ
          3.000000-02   1.000000-02   1.170000+02   5.000000+02   1.004800+04   9.000000+04
CALCIUM FLUORIDE
          7.000000-01   5.360000+01   1.570000+01   1.000000+00   3.180000+00   2.400000+00   1.600000+01
  46 2500    1
DUHE      0
          5.000000-02   5.000000-02   1.010000+02   1.010000+02   1.001410+05   1.001410+05
HEXAMETHYLENEDIAMINE
          4.780000+01   4.030000+01   1.190000+01   5.000000-01   6.000000-01   6.497860+05   1.000000+03
  47  196    1
 TAST      ABFG
        3.000000+02   1.200000-02   1.210000+02   1.210000+02   4.201910+05   2.503830+05
 FATTY ACIDS
        1.000000-01   3.540000+01   1.450000+01   1.000000-01   9.000000-01   2.350000+05   1.000000+01
  48  300    1
 DOME      ABHFG
        1.000000+01   1.000000+01   1.250000+02   5.000000+02   4.201710+05   1.704180+05
 PYRIDINE
        7.960000+01   1.480000+01   5.600000+00   1.000000-02   9.000000-01   7.554000+03   5.000000+04
  49  115    1
 TAST      ABFG
        1.000000+02   5.000000-05   1.210000+02   1.210000+02   4.202950+05   2.403350+05
 LEAD CPDS
        2.000000+00   6.060000+01   3.470000+01   5.000000-02   5.000000+00   4.200000+04   5.000000+04
  5099999    1
 DOME      ABEGZ
        5.000000-02   5.000000-02   1.080000+02   1.080000+02   1.001630+05   1.001630+05
 NAPTHALINE
        7.960000+01   1.480000+01   5.600000+00   1.000000+00   1.150000+00   7.100000+05   3.000000+01
  51  218    1
 TAST      ABED
        1.000000+00   1.000000-03   1.370000+02   5.000000+02   4.501350+05   9.000000+04
 CARBON DISULFIDE
        4.780000+01   4.030000+01   1.190000+01   1.000000+00   1.260000+00   8.200000+05   2.200000+03
  52   46    1
 TAST      ABFG
        3.000000+00   3.000000-01   1.310000+02   5.000000+02   4.200301+06   3.506100+04
 HYPOCHLORITES
        9.600000+00   7.640000+01   1.370000+01   6.000000-02   1.100000+00   8.000000+04   1.000000+03
  5399999    1
 FISH      ABI
        1.000000-01   1.000000-02   1.050000+02   1.050000+02   1.003800+05   1.003810+05
 CALCIUM HYPOCHLORITE
        7.000000-01   8.360000+01   1.570000+01   3.000000-02   2.000000+00   4.300000+04   1.850000+03
  5499999    1
 CL2       ABI
        1.000000-01   1.000000-02   1.050000+02   1.050000+02   1.003800+05   1.003810+05
 COPPER SULFATE
        2.000000+00   6.060000+01   3.470000+01   1.500000-01   3.000000+00   8.403400+04   1.000000+03
  5599999    1
 FISH      ABEGZ
        2.000000-02   2.000000-02   4.000000+00   4.000000+00   1.001300+05   1.001300+05
 SODIUM HYDROXIDE
        9.600000+00   7.640000+01   1.370000+01   2.000000+01   2.130000+00   1.920000+07   4.200000+05
  56 1390    1
 TAST      ABDIZ
        2.000000-01   1.000000-01   3.010000+02   1.180000+02   9.000000+04   1.002740+05
 ACIDS ACYLHALIDES + ANHYDRIDES
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           1.000000-01   6.540000+01   1.450000+01   5.000000+00   1.100000+00   5.209604+06   5.000000+04
  5799999    1
FISH       AHFGCZ
           0.000000      0.000000      9.040000+02   9.040000+02   0.000000      0.000000
DODECYL MERCAPTAN
           4.780000+01   4.030000+01   1.190000+01   2.600000-02   6.000000-01   1.020000+04   1.000000+03
  5899999    1
TAST       AHFG
           1.000000+00   1.000000+00   1.270000+02   5.000000+02   4.201640+05   9.000000+04
PHOSPHORIC ACID
           1.100000+00   8.570000+01   1.290000+01   1.000000+01   1.600000+00   9.600000+06   5.480000+06
  59  213    1
FISH       ALCZ
           1.000000+00   2.000000-02   1.130000+02   1.130000+02   9.000000+04   1.002300+05
NITROBENZENE
           7.560000+01   1.480000+01   5.600000+00   3.000000-02   1.190000+00   1.145000+04   1.900000+03
  60  210    1
TAST       ABF6
           1.000000+00   1.000000-02   1.280000+02   5.000000+02   4.501610+05   9.000000+04
METHYL PARATHION
           7.200000+00   8.070000+01   1.180000+01   4.000000-02   9.000000-01   3.334400+04   5.000000+01
  6199999    1
FISH       ABF6
           1.000000+03   1.000000-03   0.000000      5.900000+02   0.000000      3.901023+06
ALCOHOLS, MONOHYDRIC, UNSUBSTI
           8.000000+00   6.620000+01   2.480000+01   1.000000-02   9.000000-01   4.766000+03   1.000000+02
  6299999    1
DOME       ABF6
           5.000000+00   5.000000-04   1.320000+02   5.000000+02   4.307600+04   1.602430+05
CHROMIC ACID
           1.100000+00   8.570000+01   1.290000+01   5.000000-02   2.700000+00   4.200000+04   1.660000+06
  6399999    1
DOME       AHC6Z
           3.000000-03   3.000000-03   1.060000+02   1.060000+02   1.001230+05   1.001230+05
ALDEHYDES + KETONES
           4.780000+01   4.030000+01   1.190000+01   1.000000+01   9.000000-01   3.780608+06   5.000000+04
  6499999    1
DOME       AHFG
           0.000000      0.000000      9.040000+02   9.040000+02   0.000000      0.000000
MISC CYCLIC HERBICIDES
           7.200000+00   8.070000+01   1.180000+01   3.000000-01   9.000000-01   2.100000+05   1.000000+03
  6599999    1
FISH       ALHFG
           1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
FLUORINE HYDROFLUORIC ACID
           1.100000+00   8.570000+01   1.290000+01   1.000000+00   9.870000-01   7.000000+05   5.000000+04
  66   19    1
DOME       ALCZ
           5.000000-02   5.000000-02   1.010000+02   1.010000+02   1.001410+05   1.001410+05
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MISC ACYCLIC INSECTICIDES
          7.200000+00   8.070000+01   1.180000+01   2.000000-02   8.000000-01   1.188350+04   1.000000+03
  6799999     1
FISH      ABFG
          1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
POTASSIUM IODIDE
          9.800000+00   7.640000+01   1.370000+01   5.000000-03   3.130000+00   2.200000+03   1.275000+06
  68 1330     1
TAST      ABI
          2.000000-02   2.000000-02   1.150000+02   1.150000+02   5.003700+04   1.001520+05
SODIUM CARBONATE
          9.800000+00   7.640000+01   1.370000+01   3.400000+01   2.530000+00   1.330000+07   2.000000+04
  6999999     1
TAST      ABDI
          1.000000+01   5.000000+00   2.040000+02   6.000000+00   1.007800+04   1.002430+05
AMINES, TOTAL
          4.780000+01   4.030000+01   1.190000+01   1.000000+00   7.000000-01   2.360260+05   5.000000+04
  7099999     1
TAST      ABFGC
          4.000000+02   1.200000-02   1.210000+02   1.210000+02   4.201910+05   2.503830+05
ANILINE
          7.960000+01   1.480000+01   5.600000+00   2.000000+00   1.022000+00   3.850000+05   3.400000+04
  71  184     1
TAST      ABFGC
          2.000000+00   1.200000-02   1.210000+02   1.210000+02   4.202000+05   2.503830+05
ALUMINUM FLUORIDE
          4.660000+01   5.010000+01   3.300000+00   1.000000+00   3.070000+00   2.630000+05   5.000000+04
  72 1040     1
DOME      ABEGZ
          2.000000+00   2.000000-02   0.000000      2.000000+00   1.000000+04   2.005300+04
AMMONIA CPDS
          4.270000+01   4.790000+01   9.200000+00   1.000000+02   1.700000+00   2.300000+07   5.000000+04
  73  -30     1
FISH      AHG
          2.000000-01   1.000000-02   3.000000+00   3.000000+00   1.001930+05   1.001930+05
CARBON TETRACHLORIDE
          4.780000+01   4.030000+01   1.190000+01   5.000000+00   1.595000+00   9.700000+05   5.000000+02
  74   77     1
TAST      ABFG
          1.000000+01   1.000000-01   5.010000+02   5.000000+02   9.000000+04   2.604760+05
FURFURAL
          7.960000+01   1.480000+01   5.600000+00   1.200000+00   1.150000+00   1.900000+05   8.300000+04
  75  161     1
TAST      ABFG
          1.000000-02   1.000000+01   1.200000+02   5.000000+02   3.803440+05   4.101005+06
LINDANE
          7.200000+00   8.070000+01   1.180000+01   1.800000-02   9.000000-01   6.042000+03   5.000000+04
  7699999     1
FISH      ABFG
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          1.000000+02   1.000000-01   8.000000+02   5.000000+02   4.301600+04   2.604760+05
SULFUR DIOXIDE
          1.100000+00   4.570000+01   1.290000+01   5.000000-01   1.400000+00   1.810000+05   5.000000+04
  77  -10    1
FISH       ABCIZ
          2.000000+00  -2.000000+00   2.060000+02   2.060000+02   1.002940+05   1.002940+05
AMMONIUM PERCHLORATE
          4.270000+01   4.790000+01   9.200000+00   5.000000-01   1.950000+00   1.000000+05   5.000000+04
  7899999    1
TAST       ABG
          2.000000-01   1.000000-02   3.000000+00   3.000000+00   1.001930+05   1.001930+05
MERCURY CPDS
          2.600000+00   4.060000+01   3.470000+01   5.000000-03   3.000000+00   8.000000+02   1.000000-02
  7999999    1
DOME       ABCG
          5.000000-01   5.000000-04   1.100000+02   4.000000+04   7.006630+05   4.402085+04
ACETONITRILE
          4.780000+01   4.030000+01   1.190000+01   5.000000-01   7.800000-01   7.500000+04   5.000000+04
  80   82    1
DOME       ABFGCEZ
          1.000000+01   1.000000-03   5.010000+02   5.000000+02   9.000000+04   9.000000+04
TOLUENE
          7.960000+01   1.480000+01   5.600000+00   5.000000+01   8.600000-01   5.800000+00   4.700000+02
  81  110    1
DOME       ABHFG
          2.000000+01   1.000000-03   1.370000+02   5.000000+02   4.501350+05   2.801000+03
TRIMETHYLAMINE
          4.780000+01   4.030000+01   1.190000+01   1.000000-01   6.600000-01   1.280000+04   1.000000+03
  82    4    1
TAST       ABFG
          1.000000+01   1.200000-02   1.210000+02   1.210000+02   4.502700+05   2.503830+05
MERCURY FUNGICIDE
          7.200000+00   8.070000+01   1.180000+01   5.000000-03   1.200000+00   1.196000+03   1.000000-02
  8399999    1
DOME       ABFG
          1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
LEAD ARSENATE
          2.000000+00   4.060000+01   3.470000+01   5.000000-02   7.300000+00   6.600000+03   1.000000+03
  84 1000    1
DOME       ABEGZ
          5.000000-02   5.000000-02   1.080000+02   1.080000+02   1.001630+05   1.001630+05
ETHYL BENZENE
          7.960000+01   1.480000+01   5.600000+00   5.000000+01   8.600000-01   4.800000+00   1.400000+02
  85  130    1
FISH       ABHFG
          5.000000+00   1.000000-03   1.370000+02   5.000000+02   4.501350+05   2.601000+03
PERCHLORIC ACID
          1.100000+00   4.570000+01   1.290000+01   1.000000+00   1.800000+00   2.300000+05   1.000000+03
  86  110    1
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HCL        ABCIZ
           4.000000-01   4.000000-01   3.010000+02   3.010000+02   9.000000+04   9.000000+04
METHYLAMINES
           4.780000+01   4.030000+01   1.190000+01   6.500000-01   6.800000-01   6.774200+04   1.000000+03
  87     7     1
TAST       ABFGC
           1.000000+01   1.200000-02   1.210000+02   1.210000+02   4.201910+05   2.503830+05
PENTACHLOROPHENOL
           7.200000+00   8.070000+01   1.180000+01   2.000000-01   9.000000-01   3.795900+04   1.000000+02
  8899999      1
FISH       ABFG
           1.000000-01   1.000000-03   1.240000+02   5.000000+02   1.003030+05   3.104250+05
SODIUM HYDROSULFITE
           9.600000+00   7.640000+01   1.370000+01   5.000000-01   3.000000+00   8.000000+04   2.540000+05
  8999999      1
TAST       ABCIZ
           2.000000+00   2.000000+00   2.060000+02   2.060000+02   1.002940+05   1.002940+05
ACETALDEHYDE
           4.780000+01   4.030000+01   1.190000+01   2.000000+01   7.830000-01   1.700000+06   5.000000+04
  90    21     1
TAST       ABFG
           1.000000-02   1.000000+01   1.200000+02   5.000000+02   3.803440+05   4.101005+06
AMMONIUM CHLORIDE
           4.270000+01   4.790000+01   9.200000+00   5.000000-01   1.530000+00   4.800000+04   3.000000+05
  91   530     1
FISH       ABG
           2.000000-01   1.000000-02   3.000000+00   3.000000+00   1.001930+05   1.001930+05
ETHYLENEDIAMINE
           4.780000+01   4.030000+01   1.190000+01   5.000000-01   9.600000-01   4.000000+04   5.000000+04
  92   118     1
TAST       ABFGC
           1.000000+01   1.200000-02   1.210000+02   1.210000+02   4.201910+05   2.503830+05
ACETIC ACID. SYN.
           1.000000-01   8.540000+01   1.450000+01   2.500000+01   1.050000+00   3.600000+06   5.000000+04
  93   118     1
FISH       ABCIZ
           1.300000+01   6.000000-01   1.250000+02   5.000000+02   4.201710+05   1.607970+05
CALCIUM CARBIDE
           7.600000-01   3.360000+01   1.570000+01   1.800000+01   2.220000+00   2.300000+06   1.850000+03
  94  7447     1
CAOH2      ABI
           2.000000-01   2.000000-01   3.010000+02   4.000000+02   9.000000+04   9.000000+04
BARIUM CARBONATE
           7.600000-01   6.360000+01   1.570000+01   1.000000+00   4.430000+00   1.260000+05   2.000000+01
  9599999      1
DOME       ABEGZ
           1.000000+01   1.000000-01   2.010000+02   4.000000+02   4.002030+05   9.000000+04
CYCLOHEXYLAMINE
           4.030000+01   4.780000+01   1.190000+01   5.000000-01   8.100000-01   3.600000+04   1.000000+03
  96   134     1
TAST       ABFG
         5.000000+00   1.200000-02    1.210000+02   1.210000+02   4.502640+05   2.503630+05
SILVER NITRATE
         2.000000+00   [illegible].300000+01   3.470000+01   5.000000-02   4.300000+00   3.000000+03   1.220000+06
  97   200     1
DOME       ABEGZ
         1.000000-02   2.000000-01    1.120000+02   1.160000+02   1.005600+04   1.002700+05
ARSENIC CPDS
         4.000000+00   8.900000+01    6.500000+00   5.000000-02   5.730000+00   6.000000+03   1.000000+00
  98   615     1
DOME       ABEGZ
         3.000000+00   3.000000+00    1.020000+02   1.020000+02   1.005600+04   1.005600+04
ETHYL ALCOHOL
         8.000000+00   [illegible].620000+01   2.480000+01   5.000000+01   7.800000-01   2.400000+06   5.000000+04
  99    78     1
DOME       ABI
         5.000000+00   5.000000-04    1.320000+02   5.000000+02   4.307600+04   1.802430+05
ACETONE
         4.780000+01   4.030000+01    1.190000+01   4.000000+01   7.920000-01   1.620000+06   5.000000+04
 100    57     1
TAST       ABFG
         4.000000+02   5.000000-04    1.390000+02   5.000000+02   4.505650+05   2.403350+05
ZINC CPDS
         2.000000+00   6.060000+01    3.470000+01   1.000000+00   2.910000+00   3.600000+04   4.320000+06
 10199999      1
FISH       6
         5.000000-02   1.000000-03    1.350000+02   8.000000+00   1.003220+05   1.003230+05
ZINC CHLORIDE
         2.000000+00   6.060000+01    3.470000+01   1.000000+00   2.910000+00   3.800000+04   4.320000+06
 102   732     1
FISH       ABEGZ
         5.000000-02   1.000000-03    1.350000+02   8.000000+00   1.003220+05   1.003230+05
ETHYLENE OXIDE
         4.780000+01   4.030000+01    1.190000+01   1.000000+02   2.000000-03   3.780000+06   5.000000+04
 103    11     1
FISH       ACFG
         1.000000+02   1.000000+01    5.010000+02   5.000000+02   9.000000+05   4.101005+06
SODIUM CPDS
         9.000000+00   7.641000+01    1.370000+01   1.300000+02   2.000000+00   6.000000+06   5.000000+04
 104  1400     1
FISH       ABI
         1.000000+00   1.000000-01    [illegible].030000+02   1.160000+02   9.000000+04   1.002740+05
PHTHALIC ANHYDRIDE
         7.960000+01   1.480000+01    5.600000+00   2.500000+01   1.500000+00   7.600000+05   1.000000+04
 105   284     1
FISH       ACFG
         1.000000+01   1.000000+02    1.250000+02   1.250000+02   4.201710+05   3.601251+06
PHENYL MERCURIC ACETATE
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        7.200000+00    6.070000+01    1.180000+01    5.000000-03    9.000000-01    3.410000+02    2.000000-02
 10699999    1
DOME     ABFG
        5.000000-01    1.000000-03    0.000000       5.000000+02    0.000000       9.000000+04
ACETIC ANHYDRIDE
        1.000000-01    8.540000+01    1.450000+01    2.500000+01    1.087000+00    1.700000+06    5.000000+05
 107  140    1
ACID     0
        1.000000+01    6.000000-01    1.250000+02    5.000000+02    4.201710+05    1.607970+05
POLYHYDRIC ALCOHOLS ESTERS + E
        6.600000+00    6.620000+01    2.480000+01    1.000000+02    1.200000+00    3.743491+06    5.000000+04
 108  200    1
FISH     ABFG
        1.500000+01    1.000000+01    1.230000+02    5.000000+02    2.107000+04    4.101005+06
ZINC SULFATE
        2.000000+00    6.060000+01    3.470000+01    3.000000+00    3.540000+00    9.200000+04    5.000000+04
 109  200    1
FISH     ABCGZ
        5.000000-02    1.000000-03    1.350000+02    6.000000+00    1.003220+05    1.003230+05
MISC FUNGICIDES
        7.200000+00    6.070000+01    1.180000+01    7.000000-01    9.000000-01    3.900000+04    1.000000+02
 11099999    1
FISH     ABFG
        1.000000+03    1.000000-03    0.000000       5.000000+02    0.000000       9.000000+04
POTASSIUM CPDS
        9.800000+00    7.640000+01    1.370000+01    1.000000+02    2.000000+00    4.800000+06    5.000000+04
 11199999    1
FISH     ABI
        1.000000+00    1.000000-01    3.020000+02    1.140000+02    9.000000+04    1.002390+05
VINYL ACETATE
        4.780000+01    4.030000+01    1.190000+01    3.000000+01    9.340000-01    8.250000+05    2.000000+04
 112   73    1
TAST     ABHGZ
        1.500000+01    1.000000+01    1.230000+02    5.000000+02    2.107000+04    4.101005+06
N-PROPYL ALCOHOL
        6.600000+00    6.620000+01    2.480000+01    2.000000+01    8.000000-01    5.820000+05    5.000000+04
 113   97    1
DOME     ABFGI
        6.000000+00    5.000000-04    1.320000+02    5.000000+02    4.202820+05    1.602430+05
ETHYLAMINES
        4.780000+01    4.030000+01    1.190000+01    1.000000+00    7.000000-01    2.358300+04    5.000000+04
 114   16    1
TAST     ABFGC
        1.000000+01    1.200000-02    1.210000+02    1.210000+02    4.201910+05    2.503830+05
FUNGICIDES ACYCLIC
        7.200000+00    6.070000+01    1.180000+01    1.000000+00    9.000000-01    3.952800+04    1.000000+02
 11599999    1
FISH     ABFG
        1.000000+03    1.000000-03    0.000000       5.000000+02    0.000000       9.000000+04
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POTASSIUM HYDROXIDE
        9.000000+00   7.640000+01   1.370000+01   1.000000+01   2.040000+00   3.000000+05   9.700000+05
 116  432    1
FISH      00
        4.000000-01   1.000000-01   3.010000+02   1.140000+02   9.000000+04   1.002390+05
METHYL ETHYL KETONE.
        4.780000+01   4.030000+01   1.190000+01   2.500000+01   8.050000-01   4.378420+05   3.530000+05
 117   79    1
TAST      AUFG
        2.000000+02   5.000000-04   1.260000+02   5.000000+02   4.201600+05   2.403350+05
NITROUS OXIDE
        4.610000+01   3.230000+01   2.140000+01   1.000000+00   1.000000-03   1.400000+04   1.000000+03
 118  -88    1
HNO3      ABI
        4.000000-01   1.000000-02   3.010000+02   1.120000+02   9.000000+04   1.001950+05
SILVER CYANIDE
        2.000000+00   6.060000+01   3.470000+01   1.000000-02   3.950000+00   1.500000+02   2.300000-01
 11999999    1
DOME      ABCLGZ
        3.000000-02   3.000000-02   1.170000+02   1.170000+02   4.005600+04   1.004480+05
PARATHION
        7.200000+00   8.070000+01   1.180000+01   4.000000-01   9.000000-01   1.136100+04   2,000000+01
 12099999    1
FISH      ABFG
        1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      3.901023+06
CHLOROFORM
        4.780000+01   4.030000+01   1.190000+01   1.000000+01   1.500000+00   1.398820+05   5.000000+03
 121   61    1
FISH      ABFG
        1.600000+01   1.000000-01   1.170000+02   5.000000+02   4.202420+05   2.604760+05
CHLOROMETHANE
        4.780000+01   4.030000+01   1.190000+01   1.000000+01   2.000000-03   1.392530+05   8.000000+03
 122  -24    1
DOME      ABFG
        1.000000+01   1.000000-01   5.010000+02   5.000000+02   9.000000+04   2.604760+05
DICHLOROBENZENE O,P.
        7.960000+01   1.480000+01   5.600000+00   1.000000+01   1.300000+00   1.154070+05   1.450000+02
 123  180    1
FISH      ABFG
        1.000000+02   1.000000-01   6.000000+02   5.000000+02   4.301600+04   2.604760+05
PHOSPHORUS TRICHLORIDE
        1.100000+00   6.570000+01   1.290000+01   5.000000+00   1.500000+00   1.200000+05   5.000000+04
 124   75    1
3HCL      ABCZ
        4.000000-01   4.000000-01   3.010000+02   3.010000+02   9.000000+04   9.000000+04
CALCIUM CHLORIDE
        7.600000-01   6.360000+01   1.570000+01   1.500000+02   2.150000+00   2.700000+06   7.400000+05
 125 1600    1
DOME      ABE1Z
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           1.000000+01   2.000000-01   2.020000+02   4.000000+02   1.007400+04   9.000000+04
2,4,5-T ACID ESTORS + SALTS
           7.200000+00   8.070000+01   1.180000+01   1.500000+00   1.100000+00   2.718900+04   1.000000+03
 12699999    1
FISH      ABFGI
           1.000000+00   1.000000-06   6.000000+02   5.000000+02   1.401200+05   1.304900+05
TRICHLOROETHYLENE
           4.780000+01   4.030000+01   1.190000+01   5.500000+01   1.400000+00   5.275710+05   1.000000+03
 127   87    1
FISH      ABFGC
           1.000000+01   1.000000-01   5.010000+02   5.000000+02   9.000000+04   2.604760+05
ESTERS OF MONOHYDRIC ALCOHOLS
           8.600000+00   6.620000+01   2.480000+01   1.000000+02   9.000000-01   9.883630+05   1.000000+04
 12899999    1
FISH      ABFG
           1.500000+01   1.000000+01   1.230000+02   5.000000+02   2.107000+04   4.101005+06
ACRYLIC ACID
           1.000000-01   8.540000+01   1.450000+01   1.000000+00   1.060000+00   1.646900+04   5.000000+04
 129  142    1
FISH      ABFCZ
           1.000000+01   6.000000-01   1.250000+02   5.000000+02   4.201710+05   1.607970+05
ACETOPHENONE
           7.960000+01   1.480000+01   5.600000+00   1.700000-01   1.030000+00   1.191000+03   5.500000+03
 13099999    1
TAST      ABFG
           4.000000+01   5.000000-04   1.260000+02   5.000000+02   4.201600+05   2.403350+05
NICKEL SULFATE
           2.000000+00   6.060000+01   3.470000+01   5.000000+00   3.680000+00   4.000000+04   2.930000+05
 13199999    1
CROP      ABCGZ
           2.500000+00   2.500000+00   1.110000+02   1.110000+02   5.005100+05   5.005100+05
CALCIUM ARSENATE
           7.000000-01   8.360000+01   1.570000+01   1.000000-01   3.000000+00   1.430000+03   4.800000+00
 13299999    1
DOME      G
           0.000000      0.000000      9.030000+02   9.030000+02   0.000000      0.000000
ETHYLENE
           4.780000+01   4.030000+01   1.190000+01   2.200000+01   1.000000-03   1.750000+05   3.000000+02
 133 -103    1
FISH      ABFG
           1.000000+01   1.000000-03   5.010000+02   5.000000+02   9.000000+04   2.601000+03
SODIUM PHOSPHATE
           9.500000+00   7.640000+01   1.370000+01   2.000000+02   3.000000+00   2.600000+06   2.000000+04
 13499999    1
DOME      ABCZ
           1.000000+00   2.000000-02   1.130000+02   1.130000+02   9.000000+04   1.002300+05
METHYL METHACRYLATE
           1.000000-01   8.540000+01   1.450000+01   3.000000+01   9.800000-01   4.045860+05   1.000000+03
 135  120    1
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TAST      ABHF
          1.000000+01   1.000000+01   1.230000+02   5.000000+02   2.107000+04   4.101005+06
DODECYL BENZENE
          7.960000+01   1.480000+01   5.600000+00   1.000000+02   9.000000-01   5.800000+05   1.000000+04
 136  290     1
FISH      ABHFG
          1.000000+01   1.370000+02   0.000000      5.000000+02   4.501550+05   9.000000+04
SODIUM  METAL
          9.800000+00   7.640000+01   1.370000+01   2.000000+01   9.700000-01   2.003800+05   4.200000+05
 137  880     1
NAOH      ABDIZ
          2.000000-01   1.000000-01   3.010000+02   1.160000+02   9.000000+04   1.002740+05
BUTYLAMINES
          4.780000+01   4.030000+01   1.190000+01   5.000000-01   7.400000-01   3.000000+03   5.000000+04
 138   45     1
TAST      ABCZ
          1.000000+01   1.200000-02   1.210000+02   1.210000+02   4.201910+05   2.503830+05
SODIUM SULFATE
          9.800000+00   7.640000+01   1.370000+01   3.000000+02   2.600000+00   2.900000+06   4.760000+04
 139 1000     1
FISH      ABI
          1.000000+00   1.000000-01   3.030000+02   1.180000+02   9.000000+04   1.002740+05
SODIUM FLUORIDE
          9.800000+00   7.640000+01   1.370000+01   1.500000+00   2.560000+00   1.320000+04   4.220000+04
 140 1695     1
DOME      AHCZ
          5.000000-02   5.000000-02   1.010000+02   1.010000+02   1.001410+05   1.001410+05
CHLOROBENZENE
          7.960000+01   1.480000+01   5.600000+00   3.500000+01   1.100000+00   1.426540+05   4.880000+02
 141  132     1
FISH      ABG
          1.000000+02   1.000000-01   8.000000+02   5.000000+02   4.301600+04   2.604760+05
PHOSPHOROUS OXYCHLORIDE
          1.100000+00   8.570000+01   1.290000+01   5.000000+00   6.000000-01   4.500000+04   5.000000+04
 142  105     1
HCL       ABCI
          4.000000-01   4.000000-01   3.010000+02   3.010000+02   9.000000+04   9.000000+04
2,4,5 T ACID
          7.200000+00   3.070000+01   1.180000+01   1.500000+00   1.100000+00   1.055200+04   1.000000+02
 14399999     1
FISH      AIFG
          1.000000+00   1.000000-06   6.000000+02   5.000000+02   1.401200+05   1.304900+05
ETHANOLAMINES
          4.780000+01   4.030000+01   1.190000+01   6.000000+01   8.000000-01   2.720000+05   5.000000+04
 144  100     1
FISH      ALFGC
          1.000000+01   1.200000-02   1.210000+02   1.210000+02   4.201660+05   2.503830+05
MALEIC ANHYDRIDE
          1.000000-01   6.540000+01   1.450000+01   3.500000+01   9.300000-01   2.220000+05   5.000000+04
 145  202    1
FISH      ABFG
          1.000000+01   1.000000+02   1.250000+02   1.250000+02   4.201710+05   3.601251+06
SODIUM SULFITE
          9.600000+00   7.640000+01   1.370000+01   1.000000+02   1.460000+00   5.000000+05   1.100000+05
 146  200    1
FISH      ABI
          2.000000+00   2.000000+00   2.060000+02   2.060000+02   1.002940+05   1.002940+05
TRIETHANOLAMINE
          4.780000+01   4.030000+01   1.190000+01   2.000000+01   7.200000-01   5.960000+04   1.500000+04
 147   90    1
FISH      ABFGC
          1.000000+02   1.200000-02   1.210000+02   1.210000+02   4.201910+05   2.503830+05
CYCLOHEXANONE
          7.960000+01   1.480000+01   5.600000+00   1.100000+01   9.400000-01   2.036900+04   2.400000+04
 148   56    1
DOME      ABHFG
          1.000000+01   5.000000-04   5.010000+02   5.000000+02   9.000000+04   2.403350+05
HERBICIDES + PLANT HORMONES AC
          7.200000+00   6.070000+01   1.180000+01   1.000000+01   9.000000-01   3.669000+04   1.000000+02
 14999999    1
FISH      ABFG
          1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
ISOPROPYL ALCOHOL
          6.600000+00   6.620000+01   2.480000+01   9.000000+02   7.800000-01   2.100000+06   5.000000+04
 150   82    1
FISH      ABFG1
          2.000000+01   5.000000-04   1.339000+05   5.000000+02   4.503850+05   1.802430+05
TURPENTINE
          7.960000+01   1.480000+01   5.600000+00   1.000000+02   8.500000-01   1.680000+05   1.000000+03
 151  150    1
FISH      ABH
          5.000000-03   5.000000-03   1.220000+02   1.220000+02   2.703300+04   2.703300+04
BROMINE
          9.600000+00   7.640000+01   1.370000+01   2.000000+01   2.930000+00   6.000000+04   4.170000+04
 152   59    1
FISH      ABFG
          5.000000-02   1.000000-02   1.050000+02   1.050000+02   1.003800+05   1.003810+05
NABAM
          7.200000+00   6.070000+01   1.180000+01   5.000000-01   9.000000-01   1.361000+03   1.000000+02
 15399999    1
AQUA      ABFG
          1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
SODIUM BORATE
          9.600000+00   7.640000+01   1.370000+01   2.000000+02   1.730000+00   4.600000+05   2.010000+04
 154  320    1
DOME      ABCG1Z
          1.000000+00   1.000000-01   1.030000+02   1.030000+02   1.006300+04   1.006100+04
FERBAM
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           7.200000+00   6.070000+01   1.180000+01   1.000000+00   9.000000-01   2.331000+03   1.000000+02
 15599999    1
FISH       ABFG
           1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
UNCP
           7.200000+00   6.070000+01   1.180000+01   2.000000+00   9.000000-01   4.619000+03   1.000000+02
 15699999    1
FISH       ABFG
           1.000000+03   1.000000-02   0.000000      5.000000+02   0.000000      9.000000+04
CALCIUM PHOSPHATE DIBASIC
           7.000000-01   6.360000+01   1.570000+01   4.000000+02   3.000000+00   8.180000+05   1.800000+04
 157 1670    1
DOME       ABC
           1.000000+01   2.000000-02   2.020000+02   4.000000+02   1.007400+04   9.000000+04
HYDROGEN PEROXIDE
           1.100000+00   6.570000+01   1.290000+01   4.000000+01   1.460000+00   9.000000+04   5.000000+04
 158  152    1
FISH       ABCIZ
           2.000000-01   2.000000-01   2.030000+02   2.030000+02   6.006000+05   6.006000+05
SODIUM CHLORATE
           9.200000+00   7.640000+01   1.370000+01   2.000000+02   2.490000+00   3.400000+05   7.900000+05
 15999999    1
DOME       ABI
           1.000000+01   4.000000+00   7.000000+00   2.050000+02   6.007180+05   6.007180+05
MONOETHANOLAMINE
           4.780000+01   4.030000+01   1.190000+01   7.000000+01   1.010000+00   6.198500+04   5.000000+04
 160  170    1
FISH       ABFGC
           1.000000+01   1.200000-02   1.210000+02   1.210000+02   4.201860+05   2.503830+05
AMMONIUM ACETATE
           1.000000-01   8.540000+01   1.450000+01   5.000000-01   1.170000+00   8.450000+02   3.370000+05
 16199999    1
TAST       ABG
           2.000000-01   1.000000-02   3.000000+00   3.000000+00   1.001930+05   1.001930+05
ANTIMONY CPD
           2.000000+00   6.060000+01   3.470000+01   4.000000+01   3.000000+00   3.000000+04   1.000000+04
 162 3200    1
FISH       ABCGZ
           1.000000-01   1.000000-01   1.040000+02   1.040000+02   7.009600+04   7.009600+04
MAGNESIUM SULFATE
           7.000000-01   8.360000+01   1.570000+01   4.000000+02   2.660000+00   5.400000+05   2.600000+05
 16399999    1
DOME       ABCZ
           1.000000-01   1.000000-01   1.090000+02   1.090000+02   1.001690+05   1.001690+05
ISOOCTYL ALCOHOL
           8.600000+00   6.620000+01   2.480000+01   1.000000+02   9.000000-01   8.038100+04   1.000000+04
 16499999 \  1
FISH       ABHFG
           1.500000+02   5.000000-04   1.330000+02   5.000000+02   4.501720+05   1.802430+05
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DIETHANOLAMINE
           4.780000+01   4.030000+01   1.190000+01   1.000000+02   1.090000+00   5.830500+04   5.000000+04
 165  268    1
FISH      ABFGC
           1.200000+01   1.200000-02   1.210000+02   1.210000+02   4.201860+05   2.503830+05
PROPYLAMINES
           4.780000+01   4.030000+01   1.190000+01   2.000000+01   7.000000-01   1.154500+04   5.000000+04
 166   49    1
FISH      ABFGC
           1.000000+01   1.200000-02   1.210000+02   1.210000+02   4.201910+05   2.503830+05
N-BUTYL ACETATE
           6.600000+00   6.620000+01   2.480000+01   1.000000+02   1.100000+00   6.329600+04   1.000000+04
 167  175    1
FISH      ABHFG
           1.500000+01   1.000000+01   1.230000+02   5.000000+02   2.107000+04   4.101005+06
POTASSIUM SULFATE
           9.800000+00   7.640000+01   1.370000+01   9.000000+02   2.660000+00   6.000000+05   1.260000+05
 168 1690    1
FISH      ABI
           1.000000+00   1.000000-01   3.020000+02   1.140000+02   9.000000+04   1.002390+05
NITROANILINE
           7.960000+01   1.480000+01   5.600000+00   2.400000+01   1.440000+00   7.900000+03   1.260000+03
 169  284    1
AQUA      ABHFG
           7.000000+00   1.200000-02   1.210000+02   1.210000+02   4.202000+05   2.503830+05
PROPYL ACETATE   ISO-N
           6.600000+00   6.620000+01   2.480000+01   1.000000+02   8.870000-01   4.203800+04   1.890000+04
 170  101    1
FISH      ABHFG
           1.500000+01   1.000000+01   1.230000+02   5.000000+02   2.107000+04   4.101005+06
UREA
           4.270000+01   4.790000+01   9.200000+00   1.600000+04   1.300000+00   6.370000+06   7.800000+05
 17199999    1
FISH      ABFGI
           1.000000+01   2.000000-02   1.290000+02   5.000000+02   4.202990+05   2.202000+05
SODIUM SILICATE
           9.800000+00   7.640000+01   1.370000+01   2.400000+03   2.000000+00   1.300000+06   5.000000+04
 17299999    1
FISH      ABDZ
           2.000000-02   2.000000-02   1.190000+02   1.190000+02   7.009620+05   7.009620+05
PROPYLENE DICHLORIDE
           4.780000+01   4.030000+01   1.190000+01   1.000000+02   1.140000+00   3.040000+04   2.870000+03
 173   69    1
FISH      ABFG
           1.000000+01   1.000000-01   5.010000+02   5.000000+02   9.000000+04   2.604760+05
PROPYLENE GLYCOL
           6.600000+00   6.620000+01   2.480000+01   1.000000+03   1.040000+00   3.330000+05   5.000000+04
 174  189    1
FISH      ABFG
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          2.000000+00   2.000000-01   7.010000+02   5.000000+02   4.201320+05   3.403060+05
ETHYL CHLORIDE
          4.780000+01   4.030000+01   1.190000+01   1.000000+03   9.200000-01   2.561890+05   5.740000+03
 175   12    1
FISH      HZ
          0.000000      0.000000      9.620000+02   9.920000+02   0.000000      0.000000
BENZOYL PEROXIDE
          7.960000+01   1.480000+01   5.600000+00   4.000000+01   1.500000+00   8.537000+03   1.000000+04
 176  200    1
DOME      ALFG
          5.000000+00   1.000000-02   1.400000+02   5.000000+02   4.504380+05   9.000000+04
ETHYLENE GLYCOL
          6.600000+00   6.620000+01   2.480000+01   1.000000+04   1.100000+00   2.400000+06   5.000000+04
 177  197    1
FISH      ALFG
          2.000000+00   2.000000-01   7.010000+02   5.000000+02   4.201320+05   3.403060+05
ETHYLENIMINE
          4.780000+01   4.030000+01   1.190000+01   3.000000+01   8.300000-01   5.000000+03   5.000000+04
 178   55    1
FISH      ALFGD
          1.000000+01   1.000000-02   5.010000+02   5.000000+02   9.000000+04   9.000000+04
ETHYL ACETATE
          6.600000+00   6.620000+01   2.460000+01   1.000000+03   9.000000-01   1.469360+05   8.600000+04
 179   77    1
FISH      ALFGC
          1.500000+01   1.000000+01   1.230000+02   5.000000+02   2.107000+04   4.101005+06
PROPYLENE OXIDE
          4.780000+01   4.030000+01   1.190000+01   1.000000+03   8.000000-01   1.200000+05   6.500000+05
 180   35    1
FISH      ALHFG
          1.000000+02   1.000000+01   5.010000+02   5.000000+02   9.000000+05   4.101005+06
OXALIC ACID
          1.000000-01   8.541000+01   1.450000+01   1.000000+02   1.900000+00   2.200000+04   5.000000+04
 181  157    1
FISH      ALCGZ
          1.000000+01   6.000000-01   1.250000+02   5.000000+02   4.201710+05   1.607970+05
PROPRIONIC ACID
          1.000000-01   8.541000+01   1.450000+01   1.000000+02   9.920000-01   2.044400+04   5.000000+04
 182  141    1
FISH      ALFGCZ
          1.000000+01   6.000000-01   1.250000+02   5.000000+02   4.201710+05   1.607970+05
SODIUM METHYLATE
          4.780000+01   4.030000+01   1.180000+01   5.000000+01   2.400000+00   5.253000+03   5.000000+04
 18399999    1
FISH      ALDIZ
          1.500000+01   1.000000+01   1.230000+02   5.000000+02   2.107000+04   4.101005+06
AMYL ALCOHOL
          6.600000+00   6.621000+01   2.480000+01   3.000000+02   8.100000-01   3.220000+04   2.700000+04
 184  136    1
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FISH      ABHFG
         2.000000+01   5.000000-04   1.320000+02   5.000000+02   4.307600+04   1.802430+05
FURFURYL ALCOHOL
         6.600000+00   6.620000+01   2.480000+01   1.000000+02   1.120000+00   1.000000+04   5.000000+04
 185  171    1
FISH      ABDFG
         5.000000+01   1.000000+01   5.010000+02   5.000000+02   9.060000+04   4.101005+06
DIETHYLENE GLYCOL
         6.600000+00   6.620000+01   2.480000+01   1.500000+03   1.130000+00   1.433090+05   5.000000+04
 186  244    1
FISH      ABFG
         2.000000+00   2.000000-01   7.010000+02   5.000000+02   4.201320+05   3.403060+05
ETHYL ETHERS ALL GRADES
         4.780000+01   4.030000+01   1.190000+01   1.000000+03   8.000000-01   8.328700+04   5.000000+04
 187   35    1
FISH      ABHFG
         1.000000+03   1.000000+01   5.010000+02   5.000000+02   0.000000      4.101005+06
DIETHYLAMINE
         4.780000+01   4.030000+01   1.190000+01   1.000000+02   7.100000-01   7.045000+03   8.150000+05
 188   56    1
FISH      ABFGD
         8.000000+01   1.200000-02   1.210000+02   1.210000+02   4.201920+05   2.503830+05
POTASSIUM PYROPHOSPHATE
         9.800000+00   7.640000+01   1.370000+01   7.500000+02   2.330000+00   8.600000+04   5.000000+04
 18999999    1
FISH      ABCGZ
         1.000000+00   1.000000-01   3.020000+02   1.140000+02   9.000000+04   1.002400+04
CITRIC ACID
         1.000000-01   6.540000+01   1.450000+01   9.000000+02   1.540000+00   1.100000+05   1.000000+04
 19099999    1
TAST      ABCGZ
         1.000000+01   6.000000-01   1.250000+02   5.000000+02   4.201710+05   1.607970+05
SORBITOL
         8.600000+00   6.620000+01   2.480000+01   1.900000+03   1.200000+00   7.130000+04   5.000000+04
 19199999    1
FISH      ALFG
         2.000000+00   2.000000-01   7.010000+02   5.000000+02   4.201320+05   3.403060+05
ZINC ACETATE
         1.000000-01   8.540000+01   1.450000+01   5.000000+00   3.000000+00   5.680000+02   1.000000+03
 19299999    1
DUME      ABCGZ
         5.000000-02   1.000000-03   1.350000+02   8.000000+00   1.003220+05   1.003230+05
SODIUM ACETATE
         1.000000-01   8.540000+01   1.450000+01   1.400000+02   2.000000+00   1.573400+04   5.000000+04
 19399999    1
TAST      ABI
         1.500000+01   1.000000+01   1.230000+02   5.000000+02   2.107000+04   4.101005+06
BORIC ACID
         1.100000+00   8.570000+01   1.290000+01   2.000000+03   1.430000+00   2.140000+05   1.950000+04
 194  300     1
DOME      ABCGZ
          1.000000+00    1.000000-01    1.030000+02    1.030000+02    1.006300+04    1.006100+04
CYCLOHEXYL ALCOHOL
          7.960000+01    1.400000+01    5.600000+00    1.000000+02    9.400000-01    4.338000+03    5.670000+04
 195  161     1
FISH      ABFG
          1.000000+01    4.000000-04    5.010000+02    5.000000+02    9.000000+04    1.802430+05
TETRALIN
          7.460000+01    1.480000+01    5.600000+00    1.000000+00    9.000000-01    4.300000+01    1.000000+03
 196  207     1
FISH      ABH
          1.000000+03    1.000000-02    0.000000       5.000000+02    0.000000       2.601000+03
TRIETHYLENE GLYCOL
          8.000000+00    6.620000+01    2.480000+01    1.000000+03    1.100000+00    5.769800+04    5.000000+04
 197  280     1
FISH      ABFGI
          2.000000+00    2.000000-01    7.010000+02    5.000000+02    4.201320+05    3.403060+05
PENTANE
          4.780000+01    4.030000+01    1.190000+01    1.000000+02    6.200000-01    4.960000+03    3.600000+02
 198   36     1
FISH      ABHFG
          1.000000+01    1.000000-03    5.010000+02    5.000000+02    4.301600+04    2.801000+03
HEXYL ALCOHOL
          6.600000+00    6.620000+01    2.480000+01    1.000000+02    8.100000-01    5.280000+03    5.900000+03
 199  157     1
FISH      ABHFG
          5.000000+00    2.000000-01    1.320000+02    5.000000+02    4.307600+04    3.403460+05
ADIPIC ACID
          1.000000-01    8.540000+01    1.450000+01    8.000000+02    1.100000+00    7.000000+04    1.000000+04
 20099999     1
FISH      ABFGCZ
          1.000000+01    6.000000-01    1.250000+02    5.000000+02    4.201710+05    1.607970+05
FUMARIC ACID
          1.000000-01    8.540000+01    1.450000+01    5.000000+02    1.640000+00    4.036000+04    7.000000+03
 201  200     1
FISH      ABFGCZ
          1.000000+01    6.000000-01    1.250000+02    5.000000+02    4.201710+05    1.607970+05
DIBROMOCHLOROPROPANE
          7.200000+00    8.070000+01    1.180000+01    7.000000+01    1.200000+00    5.240000+03    1.000000+02
 20299999     1
FISH      ABFG
          1.000000+01    1.000000-01    5.010000+02    5.000000+02    9.000000+04    2.604760+05
BUTYL HYDROPEROXIDE
          4.780000+01    4.030000+01    1.190000+01    4.000000+01    8.600000-01    1.305000+03    1.000000+03
 203   55     1
DOME      ABHFG
          1.000000-01    1.000000-02    1.380000+02    5.000000+02    4.002260+05    9.000000+04
GLYCERINE SYN + NAT
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         4.780000+01   4.030000+01   1.190000+01   1.000000+04   1.200000+00   3.120000+05   5.000000+04
 204  290    1
FISH     ABFG
         1.000000-02   1.000000-02   6.000000+02   5.000000+02   3.701000+03   9.000000+04
DIPROPYLENE GLYCOL
         6.000000+00   6.620000+01   2.480000+01   1.000000+03   1.020000+00   3.324900+04   5.000000+04
 205  229    1
FISH     ABFG
         2.000000+00   2.000000-01   7.010000+02   5.000000+02   4.201320+05   3.403060+05
METHYL ACETATE
         1.000000-01   8.540000+01   1.450000+01   2.000000+02   8.000000-01   8.800000+03   1.000000+03
 206   75    1
FISH     ABFG
         1.500000+01   1.000000+01   1.230000+02   5.000000+02   2.107000+04   4.101005+06
MORPHOLINE
         7.960000+01   1.480000+01   5.600000+00   1.000000+03   9.998000-01   1.764100+04   5.000000+04
 207  126    1
FISH     ABHFGC
         2.000000+02   1.200000-02   1.210000+02   1.210000+02   4.201910+05   2.503830+05
CRESOLS  TOTAL O+M+P.
         7.960000+01   1.480000+01   5.600000+00   5.000000+03   1.000000+00   7.351700+04   3.100000+04
 208  191    1
TAST     ABFG
         1.000000-01   1.000000-03   1.240000+02   5.000000+02   1.003030+05   3.104250+05
ETHYL FORMATE
         1.000000-01   8.540000+01   1.450000+01   5.000000+00   9.200000-01   1.680000+02   5.000000+04
 209   54    1
FISH     ABHFGC
         1.500000+01   1.000000+01   1.230000+02   5.000000+02   2.107000+04   4.101005+06
ISOPROPYLACETONE
         4.790000+01   4.030000+01   1.190000+01   1.000000+04   8.000000-01   1.668520+05   1.900000+04
 210  119    1
FISH     ABHFG
         2.000000+02   5.000000-04   1.260000+02   5.000000+02   4.201600+05   2.403350+05
2 ETHYLHEXYL ACRYLATE
         1.000000-01   8.540000+01   1.450000+01   1.000000+03   8.900000-01   2.050000+04   1.000000+04
 211  130    1
FISH     ABHFG
         1.500000+01   1.000000+01   1.230000+02   5.000000+02   2.107000+04   4.101005+06
ISOPROPYL ETHER
         4.780000+01   4.030000+01   1.190000+01   1.000000+03   7.200000-01   6.108000+03   2.000000+03
 212   68    1
FISH     ABHFG
         1.000000+02   1.000000+01   5.010000+02   5.000000+02   9.000000+05   4.101005+06
LACTIC ACID
         1.000000-01   8.540000+01   1.450000+01   6.450000+02   1.200000+00   5.300000+03   1.000000+04
 213  119    1
FISH     ABFGCZ
         1.000000+01   6.000000-01   1.250000+02   5.000000+02   4.201710+05   1.607970+05
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ISOPROPYL ACETATE
          6.000000+00   6.620000+01   2.480000+01   1.000000+04   8.770000-01   4.203800+04   3.090000+04
 214   89    1
FISH      ABHFG
          1.500000+01   1.000000+01   1.230000+02   5.000000+02   2.107000+04   4.101005+06
FORMIC ACID
          1.000000-01   6.540000+01   1.450000+01   4.700000+03   1.220000+00   2.314200+04   5.000000+04
 215  100    1
AGUA      ABFGCZ
          1.000000+01   6.000000-01   1.250000+02   5.000000+02   4.201710+05   1.607970+05
BUTYRIC ACID
          1.000000-01   6.540000+01   1.450000+01   1.000000+02   9.500000-01   4.570000+02   5.000000+04
 216  163    1
AGUA      ABFGCZ
          1.000000+01   6.000000-01   1.250000+02   5.000000+02   4.201710+05   1.607970+05
MAGNESIUM CPDS
          7.000000-01   8.360000+01   1.570000+01   1.000000+02   2.000000+00   3.000000+02   1.000000+03
 21799999    1
DONE      ABCGZ
          1.000000-01   1.000000-01   1.090000+02   1.090000+02   1.001690+05   1.001690+05
TETRAETHYLENE GLYCOL
          8.000000+00   6.620000+01   2.480000+01   1.000000+03   1.010000+00   1.700000+03   5.000000+04
 218  275    1
FISH      ABFGI
          2.000000+00   2.000000-01   7.010000+02   5.000000+02   4.201320+05   3.403060+05
CALCIUM NITRATE
          7.000000-01   8.360000+01   1.570000+01   4.000000+02   2.500000+00   1.160000+02   5.000000+04
 21910000    1
DOME      0
          4.000000-01   1.000000-02   1.120000+02   1.120000+02   1.001950+05   1.001950+05
GLYOXAL
          6.000000+00   6.620000+01   2.480000+01   1.000000+04   1.140000+00   6.530000+02   5.000000+04
 220   50    1
FISH      ABFG
          1.000000-02   1.000000+01   1.200000+02   5.000000+02   3.803440+05   4.101005+06

 COMPOUNDS WHERE FDL IS GREATER THAN CC
ETHYLENEDIAMINE
          4.780000+01   4.030000+01   1.190000+01   5.000000-01   9.600000-01   4.000000+04   5.000000+04
 118   1
TAST      ABFGC
          1.000000+01   1.200000-02   1.210000+02   1.210000+02   4.201910+05   2.503830+05
METHYL ETHYL KETONE
          4.780000+01   4.030000+01   1.190000+01   2.500000+01   8.050000-01   4.378420+05   3.530000+05
  79   1
TAST      ABFG
          2.000000+02   5.000000-04   1.260000+02   5.000000+02   4.201600+05   2.403350+05
ACETONE
          4.780000+01   4.030000+01   1.190000+01   4.000000+01   7.920000-01   1.620000+06   5.000000+04
  57     1
TAST      ALFG
         4.000000+02    5.000000-04    1.390000+02    5.000000+02    4.503650+05    2.403350+05
ACETONE CYANOHYDRIN
         4.780000+01    4.030000+01    1.190000+01    1.000000-02    9.320000-01    4.849280+05    1.000000+03
 120     1
DOME      ALCLFG
         3.000000-02    3.000000-02    1.170000+02    1.170000+02    1.004800+04    1.004800+04
CARBON TETRACHLORIDE
         4.780000+01    4.030000+01    1.190000+01    5.000000+00    1.595000+00    9.700000+05    5.000000+02
  77     1
TAST      ABFG
         1.000000+01    1.000000-01    5.010000+02    5.000000+02    9.000000+04    2.604760+05
FATTY ACIDS
         1.000000-01    8.540000+01    1.450000+01    1.000000-01    9.000000-01    2.359000+05    1.000000+01
 300     1
DOME      ABHFG
         1.000000+01    1.000000+01    1.250000+02    5.000000+02    4.201710+05    1.704180+05
ALCOHOLS, MONOHYDRIC, UNSUBSTI
         8.600000+00    6.620000+01    2.480000+01    1.000000-02    9.000000-01    4.766000+03    1.000000+02
9999     1
DOME      ABFG
         5.000000+00    5.000000-04    1.320000+02    5.000000+02    4.307800+04    1.802430+05
METHYL ALCOHOL
         8.600000+00    6.620000+01    2.480000+01    1.000000-02    7.900000-01    4.600000+06    5.000000+04
  64     1
DOME      ABFGI
         3.500000+00    5.000000-04    1.320000+02    5.000000+02    4.202440+05    1.802430+05
ISOOCTYL ALCOHOL
         8.600000+00    6.620000+01    2.480000+01    1.000000+02    9.000000-01    8.038100+04    1.000000+04
9999     1
FISH      ABHFG
         1.500000+02    5.000000-04    1.330000+02    5.000000+02    4.501720+05    1.802430+05
BUTYL ALCOHOL N AND ISO
         8.600000+00    6.620000+01    2.480000+01    2.000000-01    8.000000-01    3.312480+05    1.250000+05
 100     1
TAST      ABFGI
         5.000000+00    5.000000-04    1.320000+02    5.000000+02    4.307800+04    1.802430+05
BENZALDEHYDE
         7.960000+01    1.480000+01    5.600000+00    3.000000-03    1.040000+00    3.932000+03    1.000000+03
 178     1
TAST      ABFG
         1.000000-02    1.000000+01    1.200000+02    5.000000+02    3.803440+05    4.101005+06
ACETOPHENONE
         7.960000+01    1.460000+01    5.600000+00    1.700000-01    1.030600+00    1.191000+03    5.500000+03
9999     1
TAST      ABFG
         4.000000+01    5.000000-04    1.260000+02    5.000000+02    4.201600+05    2.403350+05
ANILINE
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         7.960000+01   1.480000+01   5.600000+00   2.100000+00   1.022000+00   3.850000+05   3.400000+04
 104     1
TAST      ABFGC
         2.000000+00   1.200000-02   1.210000+02   1.210000+02   4.202000+05   2.503830+05
NITROBENZENE
         7.960000+01   1.480000+01   5.600000+00   3.000000-02   1.190000+00   1.145000+04   1.900000+03
 210     1
TAST      ABFG
         1.000000+00   1.000000-02   1.280000+02   5.000000+02   4.501610+05   9.000000+04
PHENOL
         7.960000+01   1.480000+01   5.600000+00   1.000000-03   1.070000+00   1.700000+06   6.700000+04
 182     1
TAST      ABFG
         1.000000-03   1.000000-03   1.240000+02   5.000000+02   3.201900+04   3.104250+05
BENZENE
         7.960000+01   1.480000+01   5.600000+00   1.000000-01   8.790000-01   8.500000+06   8.200000+02
 80      1
TAST      ABHFG
         1.000000+01   1.000000-03   1.370000+02   5.000000+02   4.501350+05   2.801000+03
NONYL PHENOL
         7.960000+01   1.480000+01   5.600000+00   1.000000-03   9.400000-01   2.644500+04   1.000000+01
 300     1
TAST      ABHFG
         1.000000-01   1.000000-03   1.240000+02   5.000000+02   1.003030+05   3.104250+05
PYRIDINE
         7.960000+01   1.480000+01   5.600000+00   1.100000-02   9.000000-01   7.554000+03   5.000000+04
 115     1
TAST      ABFG
         1.000000+02   5.000000-05   1.210000+02   1.210000+02   4.202950+05   2.403350+05
CHLOROBENZENE
         7.960000+01   1.480000+01   5.600000+00   3.500000+01   1.100000+00   1.426540+05   4.880000+02
 132     1
FISH      ABG
         1.000000+02   1.000000-01   8.000000+02   5.000000+02   4.301600+04   2.004760+05
DICHLOROBENZENE O.P.
         7.960000+01   1.480000+01   5.600000+00   1.000000+01   1.300000+00   1.154070+05   1.450000+02
 180     1
FISH      ABFG
         1.000000+02   1.000000-01   8.000000+02   5.000000+02   4.301600+04   2.004760+05
PHOSPHORUS PENTASULFIDE
         1.160000+00   1.570000+01   1.290000+01   1.000000-03   2.020000+00   1.280000+05   2.030000+02
 514     1
H2S       ABCI
         5.000000-02   5.000000-02   1.070000+02   1.070000+02   1.004290+05   1.004290+05
CALCIUM HYPOCHLORITE
         7.000000-01   8.360000+01   1.570000+01   3.000000-02   2.000000+00   4.300000+04   1.650000+03
9999     1
CL2       ABI
         1.000000-01   1.000000-02   1.050000+02   1.050000+02   1.003800+05   1.003810+05
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CHLOROSULFONIC ACID
          1.100000+00    [illegible].570000+01  1.290000+01  1.000000-03  1.800000+00  2.300000+05  1.000000+03
 156      1
H2S        ABCIZ
          5.000000-02    5.000000-02  1.070000+02  1.070000+02  1.004290+05  1.004290+05
POTASSIUM IODIDE
          9.600000+00    7.640000+01  1.370000+01  5.000000-03  3.130000+00  2.200000+03  1.275000+06
1330      1
TAST       ABI
          2.000000-02    2.000000-02  1.150000+02  1.150000+02  5.003700+04  1.001520+05
SODIUM SULFIDE
          9.800000+00    7.640000+01  1.370000+01  5.000000-02  1.800000+00  1.800000+05  1.540000+05
9999      1
TAST       ABCI
          5.000000-02    5.000000-02  1.070000+02  1.070000+02  1.004290+05  1.004290+05
SODIUM HYDROSULFITE
          9.800000+00    7.640000+01  1.370000+01  5.000000-01  3.000000+00  8.000000+04  2.540000+05
9999      1
TAST       ABCIZ
          2.000000+00    2.000000+00  2.060000+02  2.060000+02  1.002940+05  1.002940+05
ARSENIC CPDS
          4.000000+00    8.900000+01  6.500000+00  5.000000-02  5.730000+00  6.000000+03  1.000000+00
 615      1
DOME       ABEGZ
          3.000000+00    3.000000+00  1.020000+02  1.020000+02  1.005600+04  1.005600+04
LEAD CPDS
          2.000000+00    6.060000+01  3.470000+01  5.000000-02  5.000000+00  4.200000+04  5.000000+04
9999      1
DOME       ABEGZ
          5.000000-02    5.000000-02  1.080000+02  1.080000+02  1.001630+05  1.001630+05
LEAD ARSENATE
          2.000000+00    6.060000+01  3.470000+01  5.000000-02  7.300000+00  6.000000+03  1.000000+03
1000      1
DOME       ABEGZ
          5.000000-02    5.000000-02  1.080000+02  1.080000+02  1.001630+05  1.001630+05
NICKEL CPDS
          2.000000+00    6.060000+01  3.470000+01  5.000000-02  3.000000+00  8.000000+04  6.420000+05
 400      1
DOME       ABCGZ
          2.500000+00    2.500000+00  1.110000+02  1.110000+02  5.005100+05  5.005100+05
MERCURY CPDS
          2.000000+00    6.060000+01  3.470000+01  5.000000-03  3.000000+00  8.000000+02  1.000000-02
9999      1
DOME       ABCG
          5.000000-01    5.000000-04  1.100000+02  4.000000+04  7.006630+05  4.402085+04
ALUMINUM FLUORIDE
          4.660000+01    5.010000+01  3.300000+00  1.000000+00  3.070000+00  2.630000+05  5.000000+04
1040      1
DOME       ABEGZ
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         2.000000+00   2.000000-02   0.000000      2.000000+00   1.000000+04   2.005300+04
BARIUM CARBONATE
         7.000000-01   1.360000+01   1.570000+01   1.000000+00   4.430000+00   1.260000+05   2.000000+01
9999     1
DOME       ABEGZ
         1.000000+01   1.000000-01   2.010000+02   4.000000+02   4.002030+05   9.000000+04
MISC ACYCLIC INSECTICIDES
         7.200000+00   8.070000+01   1.180000+01   2.000000-02   8.000000-01   1.188350+04   1.000000+03
9999     1
FISH       ABFG
         1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
MISC CYCLIC INSECTICIDES
         7.200000+00   8.070000+01   1.180000+01   1.000000-03   8.000000-01   1.387550+05   1.000000-02
9999     1
FISH       ABFG
         1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      3.901023+06
MISC CYCLIC HERBICIDES
         7.200000+00   8.070000+01   1.180000+01   3.000000-01   9.000000-01   2.100000+05   1.000000+03
9999     1
FISH       ABHFG
         1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
2,4-D ACID ESTORS + SALTS
         7.200000+00   8.070000+01   1.180000+01   1.000000-02   9.000000-01   8.375000+04   3.500000+04
9999     1
TAST       ABHFG
         2.000000+00   1.000000-02   6.000000+02   5.000000+02   1.206270+05   1.308900+04
DNBP
         7.200000+00   8.070000+01   1.180000+01   2.000000+00   9.000000-01   4.619000+03   1.000000+02
9999     1
FISH       ABFG
         1.000000+03   1.000000-02   0.000000      5.000000+02   0.000000      9.000000+04
2,4-D ACID
         7.200000+00   8.070000+01   1.180000+01   1.000000-02   9.000000-01   7.713900+04   1.000000+02
9999     1
TAST       ALFG
         2.000000+00   1.000000-02   6.000000+02   5.000000+02   1.206270+05   1.304900+05
HERBICIDES + PLANT HORMONES AC
         7.200000+00   8.070000+01   1.180000+01   1.000000+01   9.000000-01   3.869000+04   1.000000+02
9999     1
FISH       ABFG
         1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
FUNGICIDES TOTAL CYCLIC
         7.200000+00   8.070000+01   1.180000+01   5.000000-03   9.000000-01   8.088500+04   1.000000-02
9999     1
FISH       ALFG
         1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
MISC FUNGICIDES
         7.200000+00   8.070000+01   1.180000+01   7.000000-01   9.000000-01   3.900000+04   1.000000+02
9999     1
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FISH      ABFG
          1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
MERCURY FUNGICIDE
          7.200000+00   6.070000+01   1.180000+01   5.000000-03   1.200000+00   1.196000+03   1.000000-02
9999      1
DOME      ABFG
          1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
FUNGICIDES ACYCLIC
          7.200000+00   6.070000+01   1.180000+01   1.000000+00   9.000000-01   3.952800+04   1.000000+02
9999      1
FISH      ABFG
          1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
FERBAM
          7.200000+00   6.070000+01   1.180000+01   1.000000+00   9.000000-01   2.331000+03   1.000000+02
9999      1
FISH      ABFG
          1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
NABAM
          7.200000+00   8.070000+01   1.180000+01   5.000000-01   9.000000-01   1.361000+03   1.000000+02
9999      1
AQUA      ABFG
          1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
ETHERS TOTAL
          4.780000+01   4.030000+01   1.190000+01   2.000000-01   9.000000-01   4.918350+05   5.000000+04
  40      1
DOME      ABHFG
          1.000000+03   1.000000+01   0.000000      5.000000+02   0.000000      4.101005+06
ETHYL ETHERS ALL GRADES
          4.780000+01   4.030000+01   1.190000+01   1.000000+03   8.000000-01   8.328700+04   5.000000+04
  35      1
FISH      ABHFG
          1.000000+03   1.000000+01   5.010000+02   5.000000+02   0.000000      4.101005+06
ETHYLENE OXIDE
          4.780000+01   4.030000+01   1.190000+01   1.000000+02   2.000000-03   3.780000+06   5.000000+04
  11      1
FISH      ABFG
          1.000000+02   1.000000+01   5.010000+02   5.000000+02   9.000000+05   4.101005+06
CARBON DISULFIDE
          4.780000+01   4.030000+01   1.190000+01   1.000000+00   1.260000+00   8.200000+05   2.200000+03
  46      1
TAST      ABFG
          3.000000+00   3.000000-01   1.310000+02   5.000000+02   4.200301+06   3.506100+04
TETRAETHYL LEAD
          4.780000+01   4.030000+01   1.190000+01   5.000000-02   1.600000+00   5.000000+05   6.000000-02
 200      1
DOME      ABFG
          5.000000-02   5.000000-02   1.080000+02   1.080000+02   1.001630+05   1.001630+05
STYRENE
          4.780000+01   4.030000+01   1.190000+01   1.000000-01   9.000000-01   4.850000+06   1.000000+03
 196     1
TAST      ABHFG
         1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      2.801000+03
AMINES. TOTAL
         4.780000+01   4.030000+01   1.190000+01   1.000000+00   7.000000-01   2.360260+05   5.000000+04
9999     1
TAST      ABFGC
         4.000000+02   1.200000-02   1.210000+02   1.210000+02   4.201910+05   2.503830+05
HEXAMETHYLENEDIAMINE
         4.780000+01   4.030000+01   1.190000+01   5.000000-01   8.000000-01   6.497860+05   1.000000+03
 196     1
TAST      ABFG
         3.000000+02   1.200000-02   1.210000+02   1.210000+02   4.201910+05   2.503830+05
HYPOCHLORITES
         9.800000+00   7.640000+01   1.370000+01   6.000000-02   1.100000+00   8.000000+04   1.000000+03
9999     1
FISH      ABI
         1.000000-01   1.000000-02   1.050000+02   1.050000+02   1.003800+05   1.003810+05
CHLORINE
         9.800000+00   7.640000+01   1.370000+01   3.000000-02   3.200000+00   1.960000+06   5.000000+04
 -35     1
FISH      ABFGCI
         1.000000-01   1.000000-02   1.050000+02   1.050000+02   1.003800+05   1.003810+05
SULFUR DIOXIDE
         1.100000+00   8.570000+01   1.290000+01   5.000000-01   1.400000+00   1.810000+05   5.000000+04
 -10     1
FISH      ABCIZ
         2.000000+00   2.000000+00   2.060000+02   2.060000+02   1.002940+05   1.002940+05
SULFUR
         1.100000+00   8.570000+01   1.290000+01   1.000000-01   1.800000+00   2.400000+06   1.000000-03
 444     1
TAST      G
         1.000000+00   1.000000+00   1.360000+02   1.360000+02   4.207100+04   4.207100+04
PHOSPHORUS
         1.100000+00   8.570000+01   1.290000+01   1.000000-01   1.800000+00   1.100000+06   3.000000+00
 280     1
FISH      ABCZ
         1.000000+00   2.000000-02   1.130000+02   1.130000+02   9.000000+04   1.002300+05
HYDROGEN SULFIDE R
         1.100000+00   8.570000+01   1.290000+01   5.000000-02   1.000000-02   6.400000+05   5.000000+04
 -20     2
TAST      0
         5.000000-02   5.000000-02   1.070000+02   1.070000+02   1.004290+05   1.004290+05
BENZOIC ACID
         1.000000-01   8.540000+01   1.450000+01   1.000000-05   1.320000+00   8.537000+03   1.000000+02
 249     1
TAST      ABCIZ
         1.000000+01   6.000000-01   1.250000+02   5.000000+02   4.201710+05   1.607970+05
CHLORINATED ISOCYANURATES
```

```
           1.000000-01    6.540000+01    1.450000+01    1.000000-02    1.200000+00    2.600000+04    1.000000+04
  200      1
DOME        ALFGCIZ
           3.000000-02    1.000000-02    1.170000+02    5.000000+02    1.004800+04    9.000000+04
CHLOROFORM
           4.780000+01    4.030000+01    1.190000+01    1.000000+01    1.500000+00    1.398820+05    5.000000+03
  01       1
FISH        ALFG
           1.000000+01    1.000000-01    1.170000+02    5.000000+02    4.202420+05    2.604760+05
CHLOROMETHANE
           4.780000+01    4.030000+01    1.190000+01    1.000000+01    2.000000-03    1.392530+05    8.000000+03
 -24       1
DOME        ALFG
           1.000000+01    1.000000-01    5.010000+02    5.000000+02    9.000000+04    2.604760+05
HALOGENATED HYDROCARBONS
           4.780000+01    4.030000+01    1.190000+01    1.000000+00    1.100000+00    5.794615+06    5.000000+04
9999       1
TAST        ALHFG
           1.000000+03    1.000000-02    0.000000       5.000000+02    0.000000       2.604760+05
TRIMETHYLAMINE
           4.780000+01    4.030000+01    1.190000+01    1.000000-01    6.600000-01    1.280000+04    1.000000+03
   4       1
TAST        ALFG
           1.000000+01    1.200000-02    1.210000+02    1.210000+02    4.502700+05    2.503830+05
TRIETHANOLAMINE
           4.780000+01    4.030000+01    1.190000+01    2.000000+01    7.200000-01    5.960000+04    1.500000+04
  90       1
FISH        ALFGC
           1.000000+02    1.200000-02    1.210000+02    1.210000+02    4.201910+05    2.503830+05
BUTYLAMINES
           4.780000+01    4.030000+01    1.190000+01    5.000000-01    7.400000-01    3.000000+03    5.000000+04
  45       1
TAST        ALCZ
           1.000000+01    1.200000-02    1.210000+02    1.210000+02    4.201910+05    2.503830+05
PHENYL MERCURIC ACETATE
           7.200000+00    8.070000+01    1.180000+01    5.000000-03    9.000000-01    3.410000+02    2.000000-02
9999       1
DOME        ALFG
           5.000000-01    1.000000-03    0.000000       5.000000+02    0.000000       9.000000+04
HERBICIDES + PLANT HORMONES CY
           7.200000+00    8.070000+01    1.180000+01    1.000000-02    9.000000-01    2.468920+05    1.000000+02
9999       1
TAST        ALFG
           1.000000+03    1.000000-03    0.000000       5.000000+02    0.000000       9.000000+04
PARATHION
           7.200000+00    8.070000+01    1.180000+01    4.000000-01    9.000000-01    1.136100+04    2.000000+01
9999       1
FISH        ALFG
           1.000000+03    1.000000-03    0.000000       5.000000+02    0.000000       3.901023+06
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METHYL PARATHION
        7.200000+00   8.070000+01   1.180000+01   4.000000-02   9.000000-01   3.334400+04   5.000000+01
9999    1
FISH     ABFG
        1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      3.901023+06
ALDRIN-TOXAPHENE GROUP
        7.200000+00   8.070000+01   1.180000+01   3.000000-03   8.000000-01   1.201830+05   1.000000-02
9999    1
FISH     ABFG
        5.000000-01   1.000000-06   1.340000+02   5.000000+02   4.307500+04   1.401200+04
INSECTICES RODENTICIDES CYCLIC
        7.200000+00   8.070000+01   1.180000+01   1.000000-03   8.000000-01   3.517550+05   1.000000-02
9999    1
FISH     ABFG
        1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
XYLENES
        7.960000+01   1.480000+01   5.600000+09   2.000000-01   8.600000-01   3.900000+06   1.000000+01
 139    1
TAST     AEHFG
        1.000000+01   1.000000-03   8.000000+02   5.000000+02   4.301600+04   2.601000+03
METHYLAMINES
        4.780000+01   4.030000+01   1.190000+01   6.500000-01   6.800000-01   6.774200+04   1.000000+03
   7    1
TAST     ABFGC
        1.000000+01   1.200000-02   1.210000+02   1.210000+02   4.201910+05   2.503830+05
PESTICIDES INSECTICIDES ACYCLI
        7.200000+00   8.070000+01   1.180000+01   2.000000-02   8.000000-01   1.376000+05   5.000000+04
9999    1
FISH     ABFG
        1.000000+03   1.000000-03   0.000000      5.000000+02   0.000000      9.000000+04
LINDANE
        7.200000+00   8.070000+01   1.180000+01   1.800000-02   9.000000-01   6.042000+03   5.000000+04
9999    1
FISH     ABFG
        1.000000+02   1.000000-01   8.000000+02   5.000000+02   4.301600+04   2.604760+05
ETHYLAMINES
        4.780000+01   4.030000+01   1.190000+01   1.000000+00   7.000000-01   2.358300+04   5.000000+04
  16    1
TAST     ABFGC
        1.000000+01   1.200000-02   1.210000+02   1.210000+02   4.201910+05   2.503830+05
ISOPRENE
        4.780000+01   4.030000+01   1.190000+01   5.000000-03   7.800000-01   1.190000+05   1.000000-02
  34    1
TAST     ABHF
        1.000000+01   1.000000-03   5.010000+02   5.000000+02   9.000000+04   2.601000+03
ACETONITRILE
        4.780000+01   4.030000+01   1.190000+01   5.000000-01   7.800000-01   7.500000+04   5.000000+04
  82    1
DOME     ABFGCEZ
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          1.000000+01   1.000000-03   5.010000+02   5.000000+02   9.000000+04   9.000000+04
CYCLOHEXYLAMINE
          4.030000+01   4.780000+01   1.190000+01   5.000000-01   8.100000-01   3.600000+04   1.000000+03
 134      1
TAST       ABFC
          5.600000+00   1.200000-02   1.210000+02   1.210000+02   4.502640+05   2.503830+05
ETHYL FORMATE
          1.000000-01   8.540000+01   1.450000+01   5.000000+00   9.200000-01   1.680000+02   5.000000+04
  54      1
FISH       ABHFGC
          1.500000+01   1.000000+01   1.230000+02   5.000000+02   2.107000+04   4.101005+06
DODECYL MERCAPTAN
          4.780000+01   4.030000+01   1.190000+01   2.000000-02   8.000000-01   1.020000+04   1.000000+03
9999      1
TAST       ABHFG
          1.000000+00   1.000000+00   1.270000+02   5.000000+02   4.201640+05   9.000000+04
NITROPHENOL
          7.960000+01   1.480000+01   5.600000+00   1.000000-03   1.400000+00   1.890000+04   1.600000+04
 200      1
TAST       ABFG
          1.000000-03   1.000000-03   1.240000+02   5.000000+02   3.305800+04   3.105800+04
TETRALIN
          7.960000+01   1.480000+01   5.600000+00   1.000000+00   9.000000-01   4.300000+01   1.000000+03
 207      1
FISH       ABH
          1.000000+03   1.000000-02   0.000000      5.000000+02   0.000000      2.801000+03
VINYL ETHER
          7.960000+01   1.480000+01   5.600000+00   1.000000+01   7.800000-01   1.120000+02   1.060000+00
  39      0
FISH       0
          1.000000+03   1.000000+01   0.000000      5.000000+02   0.000000      4.101005+06
ACRYLIC ACID
          1.000000-01   8.540000+01   1.450000+01   1.000000+00   1.060000+00   1.646900+04   5.000000+04
 142      1
FISH       ABFCZ
          1.000000+01   6.000000-01   1.250000+02   5.000000+02   4.201710+05   1.607970+05
ACRYLONITRILE
          4.780000+01   4.030000+01   1.190000+01   1.000000-02   8.000000-01   1.150957+06   5.000000+03
  78      1
DOME       ABCEFGIZ
          1.000000+01   1.000000-03   1.250000+02   5.000000+02   4.201710+05   9.000000+04
TETRAMETHYL LEAD
          4.780000+01   4.030000+01   1.190000+01   5.000000-02   1.900000+00   1.250000+05   6.000000-02
 100      1
DOME       ABFG
          5.000000-02   5.000000-02   1.080000+02   1.080000+02   1.001630+05   1.001630+05
SILVER CYANIDE
          2.000000+00   6.060000+01   3.470000+01   1.000000-02   3.950000+00   1.500000+02   2.300000-01
9999      1
```

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DONE     ABCEGZ
         3.000000-02   3.000000-02   1.170000+02   1.170000+02   4.005600+04   1.004480+05
NAPTHALINE
         7.960000+01   1.480000+01   5.600000+06   1.000000+00   1.150000+00   7.100000+05   3.000000+01
 218     1
TAST      ABED
         1.000000+00   1.000000-03   1.370000+02   5.000000+02   4.501350+05   9.000000+04

 COMPOUNDS WHERE P EQUALS 2
CALCIUM HYDROXIDE R
         7.000000-01   8.360000+01   1.570000+01   1.800000+01   2.240000+00   2.342000+06   1.850000+03
9999     2
FISH      0
         2.000000-01   1.000000-01   3.010000+02   4.000000+02   9.000000+04   9.000000+04
HYDROGEN SULFIDE R
         1.100000+00   8.570000+01   1.290000+01   5.000000-02   1.000000-02   6.400000+05   5.000000+04
 -20     2
TAST      0
         5.000000-02   5.000000-02   1.070000+02   1.070000+02   1.004290+05   1.004290+05
```

TABLE A-1. Compounds Grouped in Broad Classification Rankings

1. Insecticides Rodenticides - Cyclic:

   Bis (p-chlorophenyl) - BBB trichloroethane (DDT)#
   Dicetel*
   Endosulfon Methoxychlor*
   Hexachlorocyclohexane (Benzene Hexachloride)#
   0, 0 Diethyl o-p-nitrophenyl phosphoro thioate (Parathion)#
   0, 0 Dimethyl o-p-nitrophenyl phosphoro thioate (Methyl Parathion)#
   Aldrin#
   Chlordane*
   Dieldrin*
   Endrin*
   Heptachlor*
   Terpene*
   Polychlorinates*
   Toxaphene#
   Carbpheno Thion*
   Coumaphos Diazinon*
   Dioxathion Ronnel*
   Chlorobenzilate*
   DDD*
   Carbaryl Lindane#

   * Listed also under Misc. Cyclic Insecticides
   # Listed also individually

2. Pesticides Insecticides-Acyclic:

   1, 2 Dibromo-3-chloro propane (DBCP)#
   Methyl Bromide (Bromoethane)#
   DDVP*
   Disulfon*
   Ethion*
   Malathion*
   Naled*
   Phorate*
   TEPP*
   Methaldehyde*

3. Herbicides and Plant Hormones-Cyclic:

   Dinitrobutylphenol-ammonium salt (DNBP)#
   1-Naphthaleneacetic acid, esters, salts*
   2,4 Dichlorophenoxyacetic acid, esters, salts (2,4,D)#

TABLE A-1. (continued)

2,4,5 Trichlorophenoxyacetic acid, esters, salts (2,4,5 T)#
Barban*
2-Chloro-N-isopropyl acetanilide*
Dicamba*
Dimethyl urea Cpds*
Dinitrophenol Cpds*
Endothal*
Isopropyl phenylcabamates (IPC & CIPC)*
Maleic hydrazide*
Pichloram*
Propanil*
Triazines*
Trifluralin*
Uracils*

* Listed also under Misc. Cyclic Herbicides
# Listed also individually

4. Herbicides & Plant Hormones-Acyclic:

CDAA
Dalapon
Methancarsonic Acid's Sodium Salts
Thiocarbamate
Thiolcarbamate
Organo phosphorus herbicides
Sodium TCA

5. Fungicides Total-Cyclic:

DMTT*
Mercury Fungicides#
Phenylmercuric acetate (PMA)#
Napthenic acid, copper salt*
Pentachlorophenol (PCP)#
8-Quinolinol (*-hydroxy quinoline) copper salt*
2,4,5 Trichlorophenol, salts#
Captan*
Dinocap*
Folpet*
Glyodin*
Pentachloro nitrobenzene*
Sodium Pentachlorophenate*

* Listed also under Misc. Cyclic Fungicides
# Listed also individually

6. Fungicides-Acyclic:

Dimethyl dithiocarbamic acid ferric salt (Ferbam)#

TABLE A-1. (continued)

Ethylene bis(dithiocarbamic acid) disodium salt (Nabam)#
Ethylene bis(dithiocarbamic acid) zinc salt (Zineb)
Dithiocarbamates
Dodine
Maneb
PETD

# Listed also individually

7. LEAD Compounds

   - Lead Nitrate
   - Lead Thiocyanate
   - Lead Acetate
   - Lead Chloride
   - Lead Sulfate

8. Alcohols:

   - Methyl
   - Ethyl
   - Butyl
   - Isopropyl
   - Hexyl
   - Isoctyl
   - Octyl*
   - Decyl
   - Cetyl*

   * Not listed individually

9. Ammonia Compounds:

   - Arsenate
   - Carbonate
   - Chromate
   - Dichromate
   - Ferrocyanide
   - Fluoride
   - Hydroxide
   - Persulfate
   - Picrate
   - Sulfide
   - Sulfate*
   - Chloride*
   - Nitrate*
   - Acetate*
   - Molybdate

   * Listed individually

TABLE A-1. (continued)

10. Sodium Compounds:

    Bisulfate
    Bifluoride
    Bromide
    Cyanide
    Perodide
    Sequisilicate

11. Potassium Compounds:

    Bromide
    Chloride
    Nitrate
    Perchlorate

TABLE A-2. Test Codes

0-no test known
2-Aluminon test for Aluminum
3-Nessler test for Ammonia
4-Cuprethol test for Copper
5-Penantholine test for Iron
6-Carbon Dioxide liberation test for Carbonate
7-Ammonium Thiocyanate test for Chlorate
8-Zincon test for Zinc
9-Quinalization test for Berylium

100-Photometric or Colorimetric test for
    101-Flourine
    102-Arsenic
    103-Boron
    104-Antimony
    105-Chlorine
    106-Chromium
    107-Sulfide
    108-Lead
    109-Magnesium
    110-Mercury
    111-Nickel
    112-Nitrate
    113-Phosphate
    114-Potassium
    115-Iodine
    116-Silver
    117-Cyanide
    118-Sodium-flame photometry
    119-Silicate
    120-Aldehydes
    121-Ammines
    122-Turpentine
    123-Esters
    124-Phenols
    125-Carboxylic Acid Radicals
    126-Ketones
    127-Mercaptans
    128-Nitrobenzene
    130-Dye Visual
    131-Carbon Disulfide
    132-Primary Alcohol-Aldehyde
    133-Secondary Alcohol-Ketone
    134-Chlorinated Pesticides
    135-Zinc

TABLE A-2. (continued)

- 136-Sulfur
- 137-Aromatics
- 138-Organic Peroxides
- 139-Acetone
- 140-Benzoyl Peroxide

200-Titration Techniques for
- 201-Barium
- 202-Calcium
- 203-Peroxide
- 204-Alkalinity
- 205-Chlorate
- 206-Iodide

300-Specific Electrode for
- 301-pH
- 302-Potassium
- 303-Sodium

400-Atomic Absorption

500-Gas Chromatograph
- 501-Portable Gas Chromatograph (short chain hydrocarbons only)

600-Thin Layer Chromatography

700-Precipitation test for
- 701-Alcohol (polyhydric)

800-Reaction test listed - no detection units given

900-No need for test because
- 901-substance not persistent
- 902-substance insoluble and floats
- 903-substance insoluble and sinks
- 904-broad category classification, must look at individual compound

TABLE A-3. Literature References for Detection Tests

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90. Machine Capability

TABLE A-4. Comparison of Reported Fish Kill Incidents and Spills with Priority Rankings of Individual Hazardous Materials

	Compound	*No. of Reported Spills	Priority Ranking No.
1.	Acids & Alkalies	41	Sulfuric Acid-27 Sodium Hydroxide-52
2.	Insecticides, Pesticides, Cyclic	38	3
3.	Chlorine	30	12
4.	Parathion	21	117
5.	Ammonia	15	7
6.	Cyanide	10	Acetone Cyanohydrin-11 Hydrogen Cyanide-42
7.	Benzene	9	6
8.	Copper in Water	9	$CuSO_4$-53
9.	Phenol	8	1
10.	Toxaphene	8	18
11.	Herbicides, Cyclic	7	22
12.	Xylene	6	16
13.	DDT	5	14
14.	Dinitrophenol	5	17
15.	Toluene	5	79
16.	Ammonium Nitrate	4	19
17.	Misc. Cyclic Insecticides	3	8
18.	Styrene	3	10
19.	Fungicides, Cyclic	3	26
20.	ABS	3	--
21.	2,4 D Acid	2	33
22.	Acyclic Insecticides	2	34
23.	Misc. Acyclic Insecticides	2	65
24.	Acetone	2	98
25.	Misc. Fungicides	2	107
26.	Hydrogen Sulfide	2	Reaction Product
27.	Vinyl Chloride	2	Rejected
28.	Phosphoric Acid	1	57
29.	Aniline	1	69
30.	Pentachlorophenol	1	86
31.	Acetic Acid	1	91
32.	Phenyl Mercuric Ammonium Acetate	1	104
33.	Potassium Cyanide	1	Potassium Cmpds-108
34.	Nitrous Oxide	1	115
35.	Phosphorous Trichloride	1	121
36.	Ethylene	1	130
37.	Ethylene Glycol	1	174
38.	Lime	1	Reaction Product
39.	Heptane	1	Insoluble
40.	Methyl Chloride	1	--
41.	Phosgene	1	--
42.	Glycidle Acrylate	1	--

TABLE A-4. (continued)

	Compound	No. of Reported Spills	Priority Ranking No.
1.	Sulfur	7	Insoluble
2.	Trichlorethylene	4	124
3.	Acrylonitrile	2	4
4.	Propane	2	Rejected
5.	Propylene	2	Rejected
6.	Carbon Tetrachloride	1	72
7.	Vinyl Acetate	1	109
8.	Butane	1	Rejected
9.	Cyclohexane	1	Insoluble
10.	Glycol	1	Propylene-171 Ethylene-174
11.	Methylene	1	--
12.	Nitro Carbonates	1	--

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* The spill data is taken from report sheets obtained from officials in Pennsylvania, Illinois, and California; the U.S. "Class 'B' Poison Incidents - 1969," the U.S. report "Spills of Materials Other Than OIL - June 1, 1967 to October 17, 1969," and a U.S. Coast Guard Summary of barge casualties involving hazardous materials from 1957-1969. While these do not cover all incidences and center mostly on fish kill-type reports, they should be representative and comprise the best data available.

APPENDIX B

CRITICAL CONCENTRATION AND PHYSICAL DATA

Appendix B contains the master critical concentration and physical property table derived from currently available literature. Abbreviations used include the standard solubility abbreviations and the "cc" for critical concentration. Reaction products of hydrolysis or decomposition from contact with water are not necessarily given stoichiometrically.

The detection limit employed is a published figure for a test amenable to field application and may include spot tests or tests utilizing portable equipment. The availability of response techniques was based on the presence of accepted practical measures that would reduce the contaminant below critical concentration levels. This includes neutralization and precipitation.

Toxicity and BOD figures are referenced. The letter used corresponds to the source referenced in Table B-3. If the letter is capitalized the source gave values in addition to the one quoted; if lower case, the source gave only the quoted value. Numbers in the footnote refer to Table B-2 where additional sources are listed. The capital-lower case scheme applies here also.

TABLE B-1. Critical Concentrations and Physical Constants of Hazardous Materials

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Abietic Acid	x		3 (a)					2	250		i
Acetaldehyde		20(K)	53 (A1)			1930 (a)	93 (b2)	.02	21	.7834	-
Acetaldol								.01		1.13	-
Acetamide			13,000 (A3)			30,000 (a)		10	22.1	1.0	s
Acetic Acid	x		25 (j4)	24 (I 5)		3,360 (a6)	82 (j)	10	118.1	1.049	-
Acetic Anhydride = Acetic Acid	x		25 (j4)			1,780 (a6)		10	140	1.087	d
Acetone			13,000 (A7)	40 (I 8)		9,750 (a5)	55 $^{(D9)}$	200	55.5	.792	-
Acetone Cyanohydrin	x	.01 (A)	1-100 (NAS-3)					.03CN	120d	.932	v s
Acetonitrile	x	.5 (A5)	1,000 (A 10)			3800 (k)	0 (b)	10	82	.7828	-
Acetophenone				.17 (I 2)				40		1 .03	
Acetyl Benzoyl Peroxide			40 H_2O_2(A)					.2 O^-			s
Acetyl Chloride									52	1.105	d
Acetyl Peroxide			40 H_2O_2(A)					.2	63	Solid	sl s
Acetylene			200 (A)					10	-83.6	1.173g/1	1000 cm^3
Acetylene Dichloride								10	60.1	1.291	i
Acridine			1.5 (A11)			2140 (r)			345	1.00	s s
Acrolein			5 (A)		20 (A)	46 (a)	33 (10 day)$^{(b)}$	.01	52.5	.841	400,000
Acrylic Acid	x		1 -100(NAS-3)					10	141.9	1.062	-

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Acrylonitrile	x	.01CN⁻ (A5)	15 (A12)	.01 (I)		90 (K)	0 (b)	10	78	.797	s
Adipic Acid	x		800 (A)					10	265	1.366	15,000
Adiponitrile	x		800 (A13)				40 (b)	10			
Alanine								10	200		166,000
Alkyl Aryl Sulfonate			5 (D14)	.7 (A)				2 SO_2			
Allyl Acetate						130 (a)		15	103	.928	sl s
Allyl Alcohol			10 (A)			100 (a)	9.1 (D)	10	97	.855	∞
Ally Amine				.5 (A)				10	53	.761	∞
Allyl Bromide								10	71.3	1.398	i
Allyl Chloride			1000 -10,000 NAS-1)	4000 (I)				10	44.6	.938	i
Allylchloroformate	decomposes to Allyl Alcohol and Chloroformic Acid										
Allyldine Diacetate								15		1.07	18,000
Allyl Trichlorosilane SiO_2 + Cl2 +	SiO_2 + Cl_2 + Propylene or Allyl Chloride										
Aluminum Ammonium Sulfate	x		523 (A)		25 Al (A)			.02 A		2.45	s
Aluminum Chloride	x		.5 (A15)		25 Al (A)			.02 Al	183	2.44	200,000

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Aluminum Fluoride	x				25 Al (A)			2		3.07	s
Aluminum Nitrate	x		.3 (A)		25 Al (A)			.02 Al	150		640,000
Aluminum Oxide	x				25 Al (A)			.02 Al	2980	3.96	i
Aluminum Sulfate	x		235 (A15)		25 Al (A)			.02 Al		2.71	310,000
Aluminum Triethyl	x			(dec. to $Al(OH)_3 + C_2H_6$)				.02 Al	194		exp
N-Aminoethyl Ethanolamine			(NAS-1) 1000-10,000	.5 (A)				10			
-4-Amino-N-Toluene Sulfonic Acid	x		375 (A3)					2 SO_3			
Ammonia, Anhyd, 28% Aq		.5 (A)	25 (A16)	.5 (A5)				.2	-33	.77 g/l	899,000
Ammonium Acetate			238 (a17)	.5 NH_4^+ (A)				.2NH_4-N	d	1.17	1,480,000
Ammonium Arsenate	x As		5 (a)	.5 NH_4^+ (A)				.2N, 3As		2.31	337,000
Ammonium Carbonate	x CO_3^-		5 (A18)	.5 NH_4^+ (A)				.2N			1,000,000
Ammonium Chloride			160 (A15)	.5 NH_4^+ (A)				.2N	520	1.53	30,000
Ammonium Chromate	x Cr		240 (a15)	.5 NH_4^+ (A)				.003Cr		1.91	410,000
Ammonium Dichromate	x Cr		136 (a15)	.5 NH_4^+ (A)				.003Cr		2.15	310,000

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Ammonium Ferrocyanide	x CN	.01CN (a)	150 (A)	.5 NH_4^+ (A)				.03 CN			s
Ammonium Fluoride	x F^-		200 (A)	.5 NH_4^+ (A)				.05 F^-		1.01	1,000,000
Ammonium Hydroxide	x OH		5 (A15)	.5 NH_4^+ (A)				.2 N			s
Ammonium Molybdate	x MO		54 (A)	.5 NH_4^+ (A)				.2 N/1 MO		2.28	s
Ammonium Nitrate			800 (A)	.5 (A)				.2 N			
Ammonium Perchlorate				.5 (A)				.2 N		1.95	107,000
Ammonium Permanganate	X $KMnO_4$		2 (A)	.5 (A)				.05 Mn		2.208	79,000
Ammonium Persulfate	x Persulfate		33$KMnO_4$ (A)	.5 (A)				.2 N			v s
Ammonium Picrate	x Picrate			.5 (A)				.2 N	423	1.72	1.1
Ammonium Sulfate			66 (A15)	.5 (A)				.2 N		1.77	71
Ammonium Sulfide	x S=		100 (A18)	.01 (A)				.05 S=			v s
Ammonium Sulfite			240 (a 18)	.01 (A)				.2	150	1.41	320,000
Ammonium Thiocyanate	x SCN		114 (A18)	.01 (A)				.2	170	1.30	1,280,000

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/l)	Fish Toxicity Critical Concentration (mg/l)	Aesthetic Critical Concentration (mg/l)	Plant Toxicity Critical Concentration (mg/l)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/l)	Boiling Point (°C)	Specific Gravity	Solubility (mg/l)
Amyl Acetate			65 (A19)	.08 (I20)		6500 (K)	38 (j)	15		1.2	i
Amyl Alcohol			300 (B21)			3.3 (a)	84 (B)	20	138	.8144	27,000
Amyl Amine			30 (A)					10	104	.7614	s
Amyl Bromide								10		1.02	100
Amyl Mercaptan				.02 (A)				10	126	.857	i
Amyl Nitrite								.001 NO_2^-	117	1.0265	
Amyl Trichlorosilane → Pentane	+ SiO_2 + Cl_2										
Aniline		5 (a5)	100(A22)	2 (I8)		500 dogs (r)	49 (j)	2	184.4	1.022	34,000
Anisoyl Chloride	→ $CH_3OC_6H_4COOH$								258.8		i
Anthracene CC>Sol						3200 (S)		.5	354	1.25	i
Antimony Pentachloride	decomposes to Antimony Trichloride and Chlorine								140	2.336	hydrolyses
Antimony Pentafluoride	x							.1	149.5	2.99	S
Antimony Pentasulfide										4.12	i
Antimony Potassium Tartrate	x	/150 mg (A)	12 (A)			300 (N)		.1 Sb		2.6	80,000
Antimony Trichloride	x		9 (A)					.1 Sb	223	3.14	-

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Antimony Tri-fluoride	x		200(a)					.1 Sb	319	4.38	3,850,000
Antimony Tri-oxide		/70 mg (A)	80 (a)			20,000 (A)		.1 Sb	1550	5.2	v sl s
Arsenic Compounds	x	.05 (A)	1 (A)		1 (A)	15 (A)		3 As			s or d
Barium Acetate	x	2 (a)	10 (a)					1 Ba		2.47	590,000
Barium Carbonate	x	1 (a)	10,000 (a18) Colloidal			800 (a) Colloidal		1 Ba	Dec	4.43	20
Barium Chlorate	x							1 Ba		3.18	274,000
Barium Chloride	x		50 (A15)					1 Ba	1560	3.9	380,000
Barium Cyanide	x	.01 CN (a)						.03 CN^-			800,000
Barium Fluoride	x		10,000 (a)					.05 F^-	2137	4.9	1200
Barium Nitrate	x		200 (A)			350 gp (a)		.01 NO_3^-	d>500	3.24	82,000
Barium Per-chlorate	x							.2 ClO_4^-	400 d	2.74	s
Barium Permanga-nate	x		4KM_nO_4 (A)					.2 MnO_4^-	d		625,000
Barium Peroxide	x		40H_2O_2(A)					2.0$^-$		4.96	v sl s
Barium Sulfide	x							.05 $S^=$		4.25	d
Benzaldehyde			20 (a23)	.003 (A2)		5,000 (r)	50(10 day)(B)	.01	178	1.04	s s
Benzene Sul-fonic Acid	x		400 (A)					2 $SO_3^=$			v s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Benzene			5 (A24)	.5 (j25)		5600 (K26)	1.9 (B2)	.5	80	.879	820
Benzine Phosphorus Dichloride			50 (A)								
Benzoic Acid	x		180 (A27)	.001 (A)			46(10day)(b2)	10	249	1.32	s s
Benzonitrile	x		80 (A13)				40 (b)	10	191	1.01	s s
Benzoyl Chloride	→ dec. to HCl + Benzoic Acid								197	1.2187	d
Benzoyl Peroxide			$40H_2O_2$(A)					5	exp.		sl s
Benzyl Alcohol			360 aq (A)				63 (j)	100	205	1.04	s
Benzylamine	x		60 aq (A)					10	185	0.98	v
Benzyl Bromide			.1 (a)					2	198	1.438	i
Benzyl Chloride			10 (a)						179	1.1	i
Benzyl Chloroformate → dec.	to Chloroformic Acid and Phenol										
Beryllium Dust			100 (A)		15 (a)			.1	2970	1.85	i
Boric Acid	x		2000 (A15)					1	300	1.435	19,500
Boron Hydrides →	$H_3BO_3 + H_2$							1B			
Boron Trichloride →	$H_3BO_3 + HCl$							.4 HCl	12.5	1.434	d
Boron Trifluoride	x		15,000 (a)					.05 F	-101	2.99 g/1	106 cm^3

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Brombenzyl Cyanide								.03 CN			i
Bromine			20 (A)					.05	58.8	2.928	35,800
Bromine Penta Fluoride →	HF + HBr								135	2.49	d
Bromine Tri- fluoride →	HF + HBr								40.5	2.466	d
Bromoacetone								10	136	1.6	81 S
Bromomethane								10	356	1.7	900
Butadiene (inhibited)			71.5 (d)						10		i
Butane			>10,000 (NAS-0)					10	.6	.6	sl s
Butene									.5	.6	i
Butyl Acetate			44 (A)			4130 (a)	24 (D)	15	175	1.1	s
Butyl Acrylate			100-1000 (NAS-2)					15	145	.89	i
Butyl Alcohol			29 (a 22)	.2 (a28)		2.75 (A5)	96 (B29)	5	100	.8	125,000
Butyl Aldehyde								5	75	.82	37,000
Butyl Amine			40 (B)	.5 (A)		500 (r)	27 (D)	10	55	.7	
Butyl Hydro- peroxide			40 H_2O_2 (A)					.1	55	.86	
Butyl Lithium →	LiOH + Butane										d

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/l)	Fish Toxicity Critical Concentration (mg/l)	Aesthetic Critical Concentration (mg/l)	Plant Toxicity Critical Concentration (mg/l)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/l)	Boiling Point (°C)	Specific Gravity	Solubility (mg/l)
Butyl Mercaptan				.005 (I)				10	98	.85	sl s
Butyl Propionate								15	145	.825	
Butyraldehyde			1-100 (**S-3)				44 (D2)	5			
Butyric Acid	x		100 (A)			8790 (A)		10	163	.95	56,200
Cadmium Chloride	x	.2/25 mg (A)	5 (A)		50 (a)			.04 Cd	960	4.04	1,400,000
Cadmium Nitrate	x	.2/25 mg (A)	6 (A)		50 (a)			.04 Cd		72.0	1,090,000
Cadmium Sulfate	x	.2/25 mg (A)	1000 (A)		50 (a)			.04 Cd		4.7	760,000
Calcium →	Calcium Hydroxide + H_2								1240	1.55	d
Calcium Arsenate	x	.1 (a)	2 (a)		2 (A)			3 As			48
Calcium Carbide→	$Ca(OH)_2$ +	C_2H_2						.2	>447	2.22	d
Calcium Carbonate	x	400 Ca (A)	56,000 (a18)	50 (A)				10 Ca		2.93	15.3
Calcium Chloride	x	400 Ca (A)	500 (A18)	150 (A)	3500 (A)			10	>1600	2.15	740,000
Calcium Cyanide→	$Ca(OH)_2$ +	HCN							7000	powd	d
Calcium Floride	x	$1 F^-$ (A)				5000 gp (a)		.05 F^-	2500	3.18	16
Calcium Flou-silicate	x		50 (a)			250 gp (a)		.05 F^-		2.66	sl s
Calcium Hydroxide	x	400 Ca (A)	18 (A15)					.2	d	2.24	1850
Calcium Hypo-chlorite →	$Ca(OH)_2$ +	Cl_2						.1		powd	D
Calcium Nitrate	x	400 Ca (A)	3000 (A)					.4		2.5	1,210,000
Calcium Phosphate	x	400 Ca (A)						10		3.14	20
Calcium Sulfate	x	400 Ca (A)	633 (A18)	300 (A)				10		2.96	2100

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Camphor			1000-10,000 (NAS-1)	1.9 (a)		2200 (r)		200			
Carbon Disulfide		1 (k)	35 (A30)	1.0 (a)				3	46.3	1.26	2200
Carbon Monoxide			.1 (A11)					2	-190		28.4
Carbon Tetrachloride		5/8 gm (K/a)	100-1000(NAS-2)	5 (K)		7500 (k)	0 (j)	10	76.8	1.595	800
Caustic Potash (KOH)	x		50 (A31)		50 (K)			.4	1320	2.0044	970,000
Caustic Soda (NaOH)	x		20 (A31)		50 (A5)			.2	1390	2.13	420,000
Cetyl Alcohol-(Hexadecanol) insol								130	344	.81	i
Chenopodium Oil			10 (a)	17 (a)				5			
Chloramine-T			.4 (A)					.8			s
Chlorine			.03 (A5)	.5 (A5)	100(A5)			.1	34.6	3.2	s
Chlorine Trifluoride →	HCL + HF								11.3	1.77	d
Chlorobenzene			35 (H)			2900 (N)	1 (j)	5	132	1.1	488
Chloroform		20 (K)	10 (A5)			2180 (K)	2 (j)	16	61	1.5	10,000
Chlorohydrin			100-1000(NAS-2)					10	d	1.3	s
Chloroisocyanuric Acid	x	.01 CN (A)						.03 CN⁻	191		v s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/l)	Fish Toxicity Critical Concentration (mg/l)	Aesthetic Critical Concentration (mg/l)	Plant Toxicity Critical Concentration (mg/l)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/l)	Boiling Point (°C)	Specific Gravity	Solubility (mg/l)
Chloromethane		10(K)						10	-24.22	2.3 g/l	400 cm^3
Chlorophenol			8.1(632)	.01(I)			100(36days)(K)	.01	217	1.3	27,100
Chloropropene			25(4)					10	35	.918	v sl s
Chlorosulfonic Acid	→ H_2S+HCL							.05	158	1.76	d
Chromic Acid	x	.05(A)	1(A)		5(A)			.003 Cr	d	2.7	1,660,000
Chromium Sulfate	x	.05(A)	1(A)		5(A)			.003 Cr		3.01	123,000
Chromyl Chloride	→ H_2CrO_4 + HCL							.003 Cr	>1300	2.7	v s
Citric Acid	x		900(A11)					10		1.54	v s
Cobalt Chloride	x		16(A)		.3(A)			.1 Co	1049	3.36	450,000
Cobalt Nitrate	x		15(A)		.3(A)			.1 Co		1.87	134
Cobalt Sulfate	x				.1(A)			.1 Co		3.71	360,000
Copper Acetoarsenite (Paris Green)		Non Persistent in Water		(A)		21.9(A)		.02 Cu			1
Copper Chloride	x	3(A)	3.3(A)	4(a)				.02 Cu	993	3.39	710,000
Copper Nitrate	x	3(A)	.18(A)	4(a)				.02 Cu	170	2.04	1,370,000
Copper Sulfate	x		.15(A15)					.02 Cu	170	2.04	1,370,000
Cresol	x		3(A33)	.05(A34)		1350(A5)	95(6days)(B2)	.1	191	1	31,000
Cresotic Acid	x			.01(A)				.1			1400
Crotonaldehyde			1-100(NAS-3)			46(P)	27(10days)(b)	1-2	104	.85	180,000

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Cumene			1-100(NAS-3)			2910(r)			152	.86	i
Cumine Hydroperoxide			40 H_2O_2(A)					.2	153	1.05	
Cupric Chrome Gluconate			83(D)					.02 Cu			
Cupric Oxide			>56,000(e) (Colloidai)					.02 Cu			25
Cyanogen Chloride			1(A)					.03 CN	13.8	1.18	2500 cm^3
Cyclohexane			10(A35)(j)			29,800(a)			81.4	.77	i
Cyclohexane Carboxylic Acid (Naphthenic Acid)			5(A)					5			s s
Cyclohexanol			1-100(NAS-3)			2060(t)	3(j)	10	161	.94	56,700
Cyclohexanone			1-100(NAS-3)			3460(t)		10	156	.94	24.000
Cyclohexylamine				0.5(A)				200	134	.81	sl s
Decaborane +	$B_2O_3 + H_2$								100	.78	sl s
Decaldehyde									208	.818	i
Decene (n sol in handbook)									170	.74	i
Decyl Alcohol			>10,000(NAS-0)					1000	231	.82	i
Detergents			5(A)					1 PO_4			s
Diallyl Phthalate								15		1.117	i

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/l)	Fish Toxicity Critical Concentration (mg/l)	Aesthetic Critical Concentration (mg/l)	Plant Toxicity Critical Concentration (mg/l)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/l)	Boiling Point (°C)	Specific Gravity	Solubility (mg/l)
Diamyl Amine			5(a)					5	2.02		v sl s
Diborane →	$H_3BO_3 + H_2$								-92.5	.447	d
Dibutyl Peroxide			40 H_2O_2(A)					.20	80	.79	
Dibutyl Phthalate			1000-10,000 NAS-1				19(j)	15	340	1.4	400
Dibutyl Thiourea			30(A)					10			
Dichlorobenzene			5(B36)			4000(N)		10	180	1.3	14.5
Dichlorobutane								10	>100	>1	sl s
Dichlorodifluoromethane (non persistant									-28	1.4	i
Dichloroethylene			150 (A)					10	37	1.2	i
Dichloroethyl Ether		.2 (0)	100-1000(NAS-2)					10	178	1.22	10,200
Dichloroisopropyl Ether				.05 (I)				10	187	1.71	1,900
Dichlorophenol				.21 (T)				.01	210	1.5	sl s
2-Dichloropropane			1-100 (NAS-3)			2270(t)		10	69	1.14	2870
Dichloropropene			40aq (A)			250 (P)		10	75	1.2	i
Dicyclopentadiene			1000-10,000(NAS-1)					1000	170	.976	
Diethanolamine			100 (A37)			1820(s)	90 (10 day) (b38)	12	268	1.09	-
Diethyl Aluminum Chloride →	$AlCl_3$ +Ethane										d

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/l)	Fish Toxicity Critical Concentration (mg/l)	Aesthetic Critical Concentration (mg/l)	Plant Toxicity Critical Concentration (mg/l)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD$_5$	Field Detection Limit (mg/l)	Boiling Point (°C)	Specific Gravity	Solubility (mg/l)
Diethyl Amine			100(All)			540(a)		80	55.5	.71	815,000
Diethyl Benzene			1-100(NAS-3)					10	182	.86	i
Diethyl Dichlorosilane →	SiO$_2$ + Propane & Cl$_2$										d
Diethylene Glycol			32,000(a39)				1.5(D)	2	244	1.13	s
Diethylene Glycol Mono-Ether			1-100(NAS-3)				34(84$_{10}$day) (B)	2	210	.9	∞
Diethylenetriamine			100-1000(NAS-2)	.5 (A)		2300(P)		100	207	.95	∞
Diisobutylene			1000-10,000(NAS-1)					1000	102	.75	sl s
Diisobutyl Ketone			100-1000 (NAS-2)					1000	168	.8	i
Diisopropanolamine			40(A)			770(a)			249	.989	
Diisopropyl Peroxi Dicarbonate											
Dimethylamine			30 (All)	.42 (I36)	25 (a)			40	7.4	.68	v s
Dimethyldioxane			.005 (a)	2.5 (a)							
Dimethyl Ether		.2 (0)						10	-23	.002	74,000
Dimethyl Formamide								7 as formic acid	200	.9	∞
Diemthyl Hydrazine			100 (A)					12		>1	v s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/l)	Fish Toxicity Critical Concentration (mg/l)	Aesthetic Critical Concentration (mg/l)	Plant Toxicity Critical Concentration (mg/l)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/l)	Boiling Point (°C)	Specific Gravity	Solubility (mg/l)
Dimethyl Sulfate	H_2SO_4 + CH_3OH										
Dimethyl Sulfide						440(1)		1 SO_4	37	.84	i
Dinitro Aniline								.05 $S^=$	37.5	.845	i
Dinitrobenzene			2(A)					7		1.6	i
Dinitro Cresols			3(A40)					10, P	319	1.5	100
Dinitrophenol			100(A)	.001(A)		30(a)		2			v sl s
Dinitrotoluene			10(B)					20		1.6	5600
Dioxane		.2(0)						5 O, P 100 m	300	1.2	sl s
Dipentene			1000-10,000(NAS-1)			6,000(r)	0(10 days)(b)		105	1.03	–
Diphenylaminechloroarsine								1000	176	.86	i
Dipropylene Glycol			1000-10,000(NAS-1)					~2	100	>1	i
Divinyl Benzene	Sol <CC							2	229	1.02	–
Dodecanol									199	.93	
Dodecene							30 (b)	220	255	.83	i
Dodecyl Benzene			1-100(NAS-3)						213	.75	i
Dodecyl Mercaptan								-100	290	.9	
Dyes (all)			5 (A)	.02 (A) .02 (A)				1 .02			v sl s s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Epichlorohydrin			1-100 (NAS-3)						117	1.2	i
Ethanolamine			75(C)			2140(r)		10	100		v s
Ethers (all)		.2 (O)				2520 (ethyl) (N)		1000			∞
Ethoxy Triglycol			1000-10,000 (NAS-1)					2	25.5	1.02	
Ethyl Acetate			1000(c)			5620 (a)	36 (D2)	15	77	.9	86,000
Ethyl Acrylate			100-1000 (NAS-2)	.0067(I)		1020 (N)		15	98	.92	v sl s
Ethyl Alcohol		50(K)	7000 (A41)			7400(a5)	44 (D9)	5	78	.78	∞
Ethylamine			30 (A)b	.5(A)		400 (a)		10	16.7	.69	
Ethyl Benzene			50 (H)			3500 (N)	2.8 (B)	100	136	.86	140
Ethyl Chloride			1000-10,000 (NAS-1)					1000	12.2	.92	5,740
Ethylene			22 (A11)					10	-103	.001	300
Ethylene Cyanohydrin (Hydrocrylonitrile)	x		100-1000 (NAS-2)					50	221	1.059	∞
Ethylene Diamine		10(K)	30 (A5)	.5(A)		1160 (a5)		10	118	.96	s
EDTA			167 (A)					34			200
Ethylene Dichloride			150(a)			770(a)	.2(j)				
Ethylene Glycol			>10,000(c)				13 (D)j	2	197	1.1	∞
Ethylene Glycol monoether			100-1,000 (NAS-2)					100	170	.9	∞

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Ethylene Glycol Monoethyl Ether Acetate			100-1000(NAS-2)			5100(N)		100	182	1.11	∞
Ethylene Oxide			100-1000(NAS-2)					-2	10.7	.002	∞
Ethylenimine			1-100(NAS-3)			15(N)		10	55	.83	∞
Ethyl Ether		.2(0)				2520(N)	1(j)	1000			
Ethyl Formate							30(10 day) (b)	15	54	.92	118,000
2-Ethyl Hexanol-1		30(K)				3200(K)	88(j)	-100	183	.83	1000
2-Ethylhexyl Acrylate			100-1000(NAS-2)					15	130	.89	
Ethyl Methyl Ketone		40(K)	3400(K42)			3980(A5)			79	805	353,000
Ethyl Phthalate			1.2(a)							1.18	s s
2-Ethyl-3 Propyl Acrolein			100-1000(NAS-2)					20	175	.8	i
Fatty Acids	x	.1(a)	5(A)					10			s
Ferric Chloride	x		1(A18)			900(a)		.02 Fe			v s
Ferric Oxide	x		2(a)					0.02 Fe		2.4	i
Ferric Potassium Sulfate	x		14(A)					.02 Fe			
Ferric Sulfate	x		.1(A18)	10(A)				.02 Fe		3.1	s s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Ferrous Chloride	x	/1500 mg (a)	15 (A)	.2 (A)				.02 Fe		2.36	644,000
Ferrous Sulfate	x		6 (A)	.1 (A)				.02 Fe		2.2	s
Ferrous Oxide	x		10,000 (a18) (Colloidal)					.02 Fe		5.7	i
Ferrous Sulfide	x		10,000 (a18) (Colloidal)					.02 Fe .05 S=	Dec	4.84	6.2
Ferrous Sulfite	x		350 (a18)					.02 Fe .05 S=			v sl s
Fluorine →	HF + O_2								-188	1.69	d
Fluosulfonic Acid →	H_2SO_4 + HF								165	1.74	d
Formaldehyde		10(K)	25 (A43)	1 (I20)		800 (a5)	94 (b2)	.01	-21	.815	s
Formic Acid	x		4700 aq (a)				40 (b2)	10	100	1.22	-
Fumaric Acid	x		500 (j)				78j	10	290	1.635	7000
Furfural			1.2 (D44)	4 (a5)		135 (N)	100(2 day) (b)	.01	161	1.15	83,000
Furfuryl Alcohol			1-100 (NAS-3)					50	171	1.12	-
Gallic Acid	x		30 (A)					.01		1.69	v s
Glycerin			>10,000 (a5)			8000 (K)	45 (j)	.01	290	1.2	-
Glycol Diacetate			100-1000 (NAS-2)					50	186	1.12	143,000
Glyoxal			1000-10,000 (NAS-1)					.01	50.4	1.14	v s
Guaiacol			70 (A)	.002 (A)				50	205	1.13	s s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD$_5$	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Hafnium (metal)i									<3200	13.3	i
Heptane (cc > sol)			100a						98	.68	52
Heptanol (1)			100(A)			6.6(A)		50	176	.82	900
Heptene (Isomers)			1000-10,000(NAS-1)					1000	95	.7	i
Hexaethyl Tetraphosphate			50(A)					1 PO_4	150	1.3	
Hexafluorophosphoric Acid →	HPO_2F_2 +4HF								>100	1.65	d
Hexafluoropropylene											i
Hexamethylene Diamine				.5(A)				300	196		v s
Hexane			1000-10,000(NAS-1)					10	69	.66	138
1-Hexene								10	63	.67	i
Hexylene Glycol			100-1000(NAS-2)					100	>100	<1	s
Hexyl Trichlorosilane →	SiO_2 + Chlorohexane & Cl_2										d
Hydrazine			100 (A)			60 (a)		10	113.5	1.01	v s
Hexanol			112(A)			6.1 (a)	57 (10 day) (b)	5	157	.81	5900
Hydrochloric Acid	x		10 (A31)	32K				.4	-83.7	>1.63	∞

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Hydrofluoric Aci	x	1 F-(A5)	40 (K)								
Hydrofluosilicic Acid	x							.05 F^-	19.4	.987	∞
Hydrogen								.05 F^-	d	1.29	s
Hydrogen Bromide	x	1 Br (A)							-252	.0899	sl s
Hydrogen Chloride (Anhyd)	x		10(A31)	32 (K)				.1	126	1.49	∞
Hydrogen Cyanide	x	.01CN/50 mg(A	.05(A46)	.001(a)	< 100(a)			.4	-83.7	>1.63	→HCl
Hydrogen Peroxide	x		40(A)	>200(a)				.03	26	.687	∞
Hydrogen Sulfide			.86(A)	.05(a)				.2	152	1.46	∞
Hydroquinone			.2(A45)					.05	-61.8	1.53	s
Hydroxylamine			150(a)	.5(A)		320(a)	53(C)$\frac{BOD}{TOD}$	.2	285	1.33	s
Hypochlorite			.06(A)					.01/1.0 if NO_2 present	50	.9	s
Hypoiodite			28(A)					.1	>1000	>1	v s
Iodacetic Acid			10(a)					.02			
Iodine			28(a)					10	>100		s
Iodine Monochloride +	H10 + HOCl							.02	184	4.93	290
Isobutane									97	3.1	d
Isobutyl Acetate			1000-10,000 (NAS-1)						-6		i
								15	116	.87	53,000

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD$_5$	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Isobutyraldehyde			100-1000(NAS-2)					5	61	.79	110,000
Isodecaldehyde			1000-10,000 (NAS-1)					10			
Isodecanol			1000-10,000 (NAS-1)					100	118	.849	i
Isooctane									116	.7	i
Isooctanol			1-100(NAS-3)					200	162	.879	i
Isooctene									102	.72	i
Isooctyl Aldehyde			1000-10,000 (NAS-1)					1			
Isopentane (non persistent)								10	28	.62	i
Isophorone			1-100(NAS-3)								
Isoprene		5(a)	80(H)	.005(a)				10	34	.68	i
Isopropyl Acetate			1000-10,000 (NAS-1)			6750(a)	13(D)	15	89	.877	30,000
Isopropyl Alcohol			900(b45)				57(b)	-20	82	.78	-
Isopropylamine			40-80(b)	.5(A)		820(r)		20	34	.694	-
Isopropyl Ether			100-1000(NAS-2)			1000-10,000		100	67.5	7.2	2000
Isopropyl Formate								15	71.3	.883	21,000
Isopropyl Mercaptan				.02(A)				.01	60	.8	sl s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Lactic Acid	x		654(A11)				69(b)	10	119		s
Lactonitrile	x	.01 CN (A)	.46(A13)				60(b)	.03CN- 10 lact.			d
Lauroyl Peroxide			40 (A)					-1		powd	i
Lead Acetate	x	.05 Pb (A)	2.8 (A)		100 (A)			.05 Pb		3.25	443,000
Lead Arsenate	x	.05 Pb (A)	25 (A)		50 Pb (A5)	1050(a)		.05 Pb	>1000	7.30	v sl s
Lead Arsenite	x	.05 Pb (A)			50 Pb (A5)			.05 Pb	>1000	5.85	i
Lead Chloride	x	.05 Pb (A)	.5 (A)		50 Pb (A5)			.05 Pb	950	5.85	10,000
Lead Cyanide	x	.01CN (A) .05 Pb (A)			50 Pb (A5)			.03 CN .05 Pb		>1	i - H_2O s - acid
Lead Nitrate	x	.05 Pb (A)	10 (A18)		50 Pb (A5)			.05 Pb		4.53	376,500
Lead Oxide	x		Not toxic(a18)					.05 Pb		8.32	i
Lead Sulfate	x	.05 Pb (A)	25 (A)		50 Pb (A5)			.05 Pb		6.2	40
Lead Sulfocyanate $Pb(SCN)_2$	x	.01CN (A) .05Pb (A)			50 Pb (A5)			.03CN .05Pb		3.82	
Lithium (metal)→	LiOH + H_2								1336	.534	d
Lithium Aluminum Hydride →	H_2 + Al $(OH)_3$ + LiOH								d		d
Lithium Amide →	NH_3 + LiOH								430	1.178	d
Lithium Carbonate	x	5 Li(a)'	300 (A)					.2 Li	1310	2.11	15,400
Lithium Chloride	x	5 Li(a)	100 (A)					.2 Li	1325	2.07	540,000

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/l)	Fish Toxicity Critical Concentration (mg/l)	Aesthetic Critical Concentration (mg/l)	Plant Toxicity Critical Concentration (mg/l)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/l)	Boiling Point (°C)	Specific Gravity	Solubility (mg/l)
Lithium Ferro Silicon	x	5 Li(A)						.2 Li			
Lithium Fluoride	x	5 Li(A)	20,000(a)			200 SP (a)		$.2L/.05F^-$	1676	2.63	2700
Lithium Hydride+	$LiOH + H_2$									.82	d
Lithium Hydroxide	x	5 Li(A)						.2Li/.2OH	d	143	127,000
Lithium Hypochlorite	x	5 Li(A)	.06 (A)					.2Li/.1Cl	>100		s
Lithium Peroxide	x	5 Li(A)	40 H_2O_2 (A)					$.2Li/.2O^=$			s
Lithium Silicon	x	5 Li(A)						.2 Li			
Lithium Sulfate	x	5 Li(A)						.2 Li		2.121	260,000
Magnesium Metal+	$Mg(OH)_2 + H_2$							$.1Mg^{++}$	1107	1.74	i
Magnesium Arsenate	x									2.6	i
Magnesium Chloride	x	$100Mg^{++}$ (A)	400 (A15)	170 (A)	2000 (A)			.1 Mg	1412	2.3	542,000
Magnesium Fluoride	x		10,000 (a)			1000 SP (a)		$.1Mg/.05F^-$	2239	2.9	76
Magnesium Nitrate	x		300(A)	500 (A)				$.1Mg/.01\ NO_3$		2.02	s
Magnesium Perchlorate	x							.1 Mg	d	2.6	499,000
Magnesium Peroxide	x							.1 Mg			i

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Magnesium Silicofluoride	x		50(a)			200 gp(a)		.1Mg/.05F		1.79	600,000
Magnesium Sulfate	x		10,000(A18)	400(A)				.1Mg		2.66	260,000
Maleic Anhydride → Maleic Acid	x		35(A47)				77(C) $\frac{BOD}{TOD}$	10	202	.93	s
Manganese Chloride	x		300 (A)					.01 Mn	1190	2.98	723,000
Manganese Nitrate	x		40 (A)					.01 Mn	130	1.82	4,264,000
Manganese Sulfate	x		500 (A)		150(A)			.01 Mn		2.1	1,503,000
Mercaptans (dodecyl)			1(A)	.02(A)				.01			v sl s
Mercaptoethanol				.1(I)				.05			
Mercuric Ammonium Chloride		.005 Hg(A)						.5		15.7	1400
Mercuric Benzoate		.005 Hg(A)	.02(A)					.01 Hg			250
Mercuric Bromide		.005Hg(A)						.01 Hg	322	6.1	6100
Mercuric Chloride		.005 Hg(A)	.05(A)			37(r)		.01 Hg	d	4.998	250,000
Mercuric Cyanide		.005 Hg(A)	.2(A)					.01Hg/.03 CN	d	3.996	93,000
Mercuric Iodide		.005 Hg' (A)						.01 Hg	354	6.2	v sl s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Mercuric Nitrate		.005 Hg(A)	.015(A)					.01 Hg	>100	4.39	v s
Mercuric Oleate		.005 Hg(A)	.02(A)					.01 Hg			
Mercuric Oxide		.005 Hg(A)						.01 Hg		11.14	52
Mercuric Oxycyanide		.005 Hg(A)	.02(A)					.01Hg/.03 CN	d	4.437	12,500
Mercuric Potassium Cyanide		.005 Hg(A)						.01 Hg/ .03 CN		powd	
Mercuric Salicylate		.005 Hg(A)	.02(A)					.01 Hg		powd	
Mercuric Sulfate & Subsulfate	→ HgO + H_2SO_4							.01 Hg	d	6.47	d
Mercuric Sulfocyanate		.005 Hg(A)						.01 Hg		powd	
Mercurous Bromide								.01 Hg	345	7.3	.04
Mercurous Chloride		.005 Hg(A)						.01 Hg			
Mercurous Gluconate		.005 Hg(A)						.01 Hg		Solid	
Mercurous Iodide		.005 Hg(A)						.01 Hg	d	7.7	v sl s
Mercurous Nitrate	→ H_2NO_3 + HgO							.01 Hg/ .01 NO_3^-		4.79	d

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Mercurous Sulfate		.005 Hg(A)						.01 Hg	d	7.56	600
Mercury		.005 Hg^+(A)	.008Hg^+(A)					.01 Hg	356	13.54	i
Mercury Acetate		.005 (A)						.5 Hg		d	7500
Mesitylene				.0005 (I)				.01	164	.865	i
Mesityl Oxide			1-100 (NAS-3)			1120 (N)		200	128	8.5	30,000
Methane (non persistent)									-161	.0007	60
Methyl Acetate								15	57	.92	319,000
Methyl Acetylene								200	.23	.67	v sl s
Methyl Acrylate			100-1000 (NAS-2)					15	85	.95	v sl s
Methyl Alcohol		.01 (est. A)	250 (A48)			9.1 (a)	90 (a38)	3.5	64	.79	-
Methyl Amines			30(A11)	.65 (I)				10	6.5	.769	s
Methyl Amyl Acetate			1000-10,000 (NAS-1)					15	146	.85	
Methyl Amyl Alcohol			100-1000 (NAS-2)				17(10 day) (b)	50	131	.81	
Methyl Bromide (incl. mixtures)			1000-10,000 (NAS-1)					1000	3.56	1.7	900
Methyl Butyraldehyde			1-100 (NAS-3)					1	92	.8	sl s
Methyl Chloride (inc. mixtures)		10 (K)	1000-10,000 (NAS-1)					10	-24	.002	8000

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Methyl Chloroformate →	Methanol + Chloroformic Acid								71	1.2	d
Methyl Dichlorosilane →	SiO_2 + Methane + Cl_2										d
Methylene Chloride			100-1000(MAS-2)					50	40	1.3	2000
Methyl Ether		.2(O)						10	-20.65	.002	79,000
2-Methyl, 5-Ethyl Pyridine			100-1000(MAS-2)	.05(I)				1000	174	.91	i
Methyl Formal (and Formate)			100-1000(MAS-2)					10 Formal 28 Formate	31	.98	300,000
Methyl Hydrazine			100 (A)					10	87.5		v s
Methyl Isobutyl Carbinol								20	131	.8	18,000
Methyl Isobutyl Ketone			1000-10,000 (MAS-1)			4570 (N)	22(10 days) (b29)	200	119	.8	19,000
Methyl Mercaptan			.5(A)	.02(A)				.02	7.6	.86	sl s
Methyl Methacrylate			400(M)	30				15	120	.98	i
Methylnaphthoquinone			.3(a)					.2			
Methyl Salicylate				.035(a)				.03	223.3	1.537	740

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Mineral Spirits #10			1000-10,000 (NAS-1)					1000	150	.8	
Monobromotrichlororether									104	1.9	i
Monochloracetic Acid	x							5	189	1.58	v s
Monochloroacetone								20	119	1.15	s
Monochlorodifluoro Methane (not persistent)									-40.8		i
Monochlorofluoroethane										71	i
Monoethanolamine			40-70(C)				63 (10 day) (b38)	10	170	1.01	s
Monoethylamine			50(b)					10	16	.7	-
Monofluorophosphoric Acid	x	.1(A)						.05 F⁻		1.8	-
Monoisopropanolamine			25(A)	.5 (A)			5(D)	5	160	.96	
Monomethyl Hydrazine			100(A)					10	87.5		v s
Morpholine			100-1000(NAS-2)			1600(S)	0.9(D2)	200	126	.9998	-
Motor Fuel Anti-Knock Compound		.05 Pb(A)						.05 Pb			sl s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Naphthalene		/5g lethal(K)	10 (A49)	1(a)K			0(j)	1	217	1.15	30
Naphthalic Acid	x		5(A)					5	>270		s s
Naphthol			.2(A40)	.5(A50)			93 (12 days)	1	288	1.1	s s
Naphthoquinone			.5(A2)				38(j)$^{(b2)}$	.2	>100	1.45	s
B-Naphthylamine				.05(A)				.5	306	1.061	i
Nickel Ammonium Sulfate	x	1(A)	.05(A)		.5(A)			2.5 Ni			v s
Nickel Carbonyl	x		.05(A)		.5(A)	Highly Toxic		2.5 Ni	43	1.32	180
Nickel Chloride	x	1(A)	5(A)		.5(A)			2.5 Ni	973	3.55	642,000
Nickel Cyanide	x				.5(ℓ)			2.5 Ni .03 CN			i
Nickel Nitrate	x	1(A)	1(ℓ)		.5(A)			2.5 Ni .01 NO_3^-	136	2.05	2,385,000
Nickel Sulfate	x	1(A)	16(A)		5(A)			2.5		3.68	293,000
Nicotine Hydrochloride								20			s
Nicotine Salicylate Tartate & Sulfate			.3(B)					20	247		s
Nitrating Acid	Combination of Nitric and Sulfuric										
Nitric Acid	x	15(A)	1(A15)					.01 NO_3^- .4 pH	86	1.5	-

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Nitroaniline			24(A)					7	284	1.44	1260
Nitrobenzene			20(A)	.03(A)			O(j)	1.0	210	1.19	1900
Nitrochloro Benzene									235	1.5	i
Nitroethane								10	114	1	4500
Nitrogen			20 (lethal when supersaturated) (a)						-195.8	1.25	15.6
Nitrohydrochloric Acid	$HCl + HNO_3$										d
Nitromethane								10	10.1	1	10,000
Nitrophenol			5(A51)	.001(A)				.001	200	1.4	16,000
Nitropropane			1-100(NAS-3)					10	132	1	14,000
Nitrosyl Chloride →	$NO_2 + HCl$								-5.5	.003	d
Nitrotoluene			14(A)					5	231	1.1	498
Nitrous Oxide (Tetraoxide) →	$H_2\ NO_3$							.01 NO_3^-	-88.4	Gas	s
Nonane			100-1000 (NAS-2)					10	150	.7	i
Nonene			1000-10,000 (NAS-1)					20	146	.72	i
Nonyl Alcohol								10	213	.82	i
Nonyl Phenol			1-100(NAS-3)	.001(A)				.1	300	.94	

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Octodecyl Trichlorosilane →	Cl_2 + Chloroacetodecane (1) + S_1O_2										
Octyl Alcohols			50(A8)	.05(I8)							d
Octyl Trichlorosilane →	Cl_2 + Chlorooctane + S_1O_2						37(j5)	10	194	.83	i
Oil of Vitriol →	H_2 SO_4										d
Oleic Acid	x	.1(a)						1			
Oleum →	H_2 SO_4								286	.89	i
Ortho-Nitroaniline											
Oxalic Acid	x		100(A48)					7	286	1.4	890
Oxydipropionitrile	x		4000(A13)				40(b2)	10	157	1.9	s
Oxygen (non toxic)							0(s)	10			
Oxygen Difluoride →	HF + O_2								-182	1.4	s
Paraformaldehyde									-144	1.9	d
Paraldehyde								.01	54		170,000
Pentaborane →	H_3BO_3 + H_2				1(A)			3.6	124	.99	58,800
Pentane			100(A)						65		d
Peracetic Acid	x		5(a)					10	36	.62	360
Perchloric Acid	x		1(a)					.1	105	1.15	s
								.4	110	1.8	v s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Perchloroethylene			1-100 (NAS-3)					1000	121	1.6	i
Perchloro-Methyl-Mercaptan				.02 (A)				.02	149	1.7	
Perchloryl Fluoride		1F-(A)						.05 F^-	-46.8	Gas	
Petroleum Ether			1000-10,000 (NAS-1)					10	40	.635	s
Phenanthrene			5 (B)					5	340	1.18	i
Phenol			.1 (A24)	.001 (A34)	1000 (A)		42 (10 days) (B2)	.001	182	1.07	67,000
Phenylcarbylamine Chloride									208	1.3	
Penylethanolamine				.5 (A)				.5	285	1.1	
Phenyltrichlorosilane	→ Cl_2 + Chlorophenol + S_iO_2										d
Phosphine		.05 (a)	3.6 (a)					1 PO_4	Gas		3000
Phosphoric Acid	x		1-100 (A18)	200 (K)				1	213	1.8	→ H_3PO_4 548,000
Phosphoric Anhydride	→ H_3PO_4		25 (e)					1			d
Phosphorus	x		.1-1 (NAS-4)					1	280	1.8	3
Phosphorus Oxybromide	→ HB + H_3PO_4								137	2.1	d

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Phosphorus Oxychloride →	$H_3PO_4 + HCl$										
Phosphorus Pentachloride →	$HCl + H_3PO_4$								105	1.6	d
Phosphorus Pentasulfide →	$H_2S + H_3PO_4$										
Phosphorus Sesquisulfide									514	203	d
Phosphorus Tribromide →	$HBr + H_3PO_4$								407	2.03	i
Phosphorus Trichloride →	$HCl + H_3PO_4$								172	2.8	d
Phthalic Anhydride	x		>56 (h)						75	1.5	d
Picric Acid	x		30(b)	.5(a)		1600(M)		10	284	1.5	v sl s
Polybutene								10	300	1.7	1400
Polypropylene Glycol Methyl Ether		.2(o)									
Potassium (metal) →	$KOH + H_2$										
Potassium Acetate	x			1020(a)					760	.86	d
Potassium Arsenate	x		230(A)					1 K		1.8	2,530,000
Potassium Arsenite	x		2(A)					1K/3As 1K/3As			188,000 v s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/l)	Fish Toxicity Critical Concentration (mg/l)	Aesthetic Critical Concentration (mg/l)	Plant Toxicity Critical Concentration (mg/l)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD$_5$	Field Detection Limit (mg/l)	Boiling Point (°C)	Specific Gravity	Solubility (mg/l)
Potassium Bifluoride	x		100 (a)					1K/.05F⁻		2.37	410,000
Potassium Bromate	x							1K/1Br	d	3.27	31,000
Potassium Chlorate	x		1000 (A)					1K/1Cl	d	2.32	>1000
Potassium Chloride	x		400 (A)E	350 (A)				1K/1Cl	1500	1.98	347,000
Potassium Chromate	x	.05 (A)	75 (A15)	6 (A)	19 (A)			.003Cr	1000	2.7	62,900
Potassium Cupric Cyanide	x	.01CN (A)						.03CN			v s
Potassium Cyanide	x	.01CN (A)	.4 (A52)				0 (7 days) (b)	.03CN		1.52	v s
Potassium Dichloroisocyanurate	x	.01CN (A)						.03CN⁻			
Potassium Dichromate	x		60 (A15)		14 (A)			.003Cr	500	2.69	49,000
Potassium Ferricyanide	x	.01 CN (A)	2 (A)					.03CN	d	1.85	330,000
Potassium Ferrocyanide	x	.01 CN (A)	2 (A)					.03CN	d	1.85	278,000
Potassium Fluoride	x		1500 (a)			245 (a)		.05 F⁻	1505	2.48	923,000

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Potassium Hydroxide	x		50 (A15)	10 (A)				.4	132	2.04	970,000
Potassium Iodide	x		7.5 (a)	.005 (a)		1982 Mice (a)		.02	1330	3.13	1,275,000
Potassium Nitrate Potassium Nitrite			100 (A15) 50 (A)					.01 NO_3^- .001 NO_2^-	d	2.1 1.9	133,000 2,810,000
Potassium Perchlorate	x		.06 (a)					.2		2.52	7,500
Potassium Permanganate	x		3 (A18)					.2	d	2.7	28,300
Potassium Peroxide	x		40 H_2O_2 (A)					.2			v s
Potassium Persulfate	x							.2	>100	2.4	
Potassium Phosphate	x		750 (a18)					2	750	2.3	s
Potassium Silicofluoride	x		50 (a)					.05 F^-			s s
Potassium Sulfate	x		900 (A)					1	1690	2.66	120,000
Potassium Sulfide	x		3.5 (A)	.05 (A)				.05 $S^=$	150	2	s
Potassium, Thiocyanate	x	.01 CN (A)	200 (A)					.03 CN	>500	1.89	1,772,000
Propane (non persistent)									-42	.002	130
Propiolactone			100-1000 (NAS-2)					10	155	1.14	

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/l)	Fish Toxicity Critical Concentration (mg/l)	Aesthetic Critical Concentration (mg/l)	Plant Toxicity Critical Concentration (mg/l)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/l)	Boiling Point (°C)	Specific Gravity	Solubility (mg/l)
Propionaldehyde			100-1000(NAS-2)								
Propionic Acid	x		100-(A)				95(b)	10	61		v s
Propionic Anhydride →	Propanol +	Propionic Acid					56(j)	10	141	.992	∞
n-Propyl Acetate			100-1000(NAS-2)						169	1.03	d
n-Propyl Alcohol		20(K)	300(A43)				1000-10,000	15	101	.887	18,900
Propylamine			20(B)	.5 (A)		3,300(A5)	94(b2)	6	97	.8	∞
Propylene			1000-10,000(NAS-1)					10	48.7	.7	s
Propylene Butylene Polymer								1000	-47	.002	880
Propylene Glycol			1000-10,000(NAS-1)								i
Propylene Imine							2.2(D)	2	189	1.04	∞
Propylene Oxide			1000-10,000(NAS-1)								
Propylene Tetramer								100	35	.8	650,000
Propyl Mercaptan				.02(A)							i
Propyl Nitrate								.02	58	.83	v sl s
Propyl Trichlorosilane →	Cl_2 + Chloropropene + SiO_2							5	110	1.05	v sl s
Pyridal Mercuric Acetate		.005 Hg(A)	10(A)					.5 Hg			d

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Pyridine			400(A53)	.01(I21)		1600(S)	100(3days)(b)	100	115	.9	-
Pyrocatechol			15(A)	2.5(s)		3890(s)		1	240	1.6	451,000
Pyrogallol			20(A11)					1	309	1.453	625,000
Pyro Sulfuryl Chloride →	HCl + SO_2 + SO_3										d
Pyroxylin										1.66	
Quinoline			5(A)b	.5(950)				2	237	1.09	s
Quinone			5(A)			130(t)		2	>115		s s
Resins			1(s)								
Resorcinol			35(A11)	30(A)			61(j)	.1	281	1.27	s
Salicylic Acid	x		1500(s)	.01(A)				.1	211	1.44	s
Saponins	x		5.0(A)	17(s)				10			
Selenium (Colloidal)	x	.01(A)	2.0(A)		0.1(A)	3		1	685	4.81	i
Silicon Chloride (tetra) →	HCl + SiO_2								57	1.48	d
Silicon Tetrafluoride →	HF + SiO_2								-65	4.7	d
Silver Cyanide	x ,	.01CN(A)						.8Ag .03 CN	d	3.95	.23
Silver Nitrate	x	.05 Ag(A)	.04 Ag(A)					.8 Ag .01 NO_3	d	4.3	1,220,000

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Sodium (metal) →	$NaOH + H_2$								880	.97	d
Sodium Acetate			5200(a2)	140(A)			45(j)	1 Na	>300	1.53	1,190,000
Sodium Aluminate	x		100(A15)					.02 Al			s
Sodium Aluminum Hydride →	$H_2 + NaOH$	$+ Al(OH)_3$									d
Sodium Amide →	$NH_3 + NaOH$								400		d
Sodium Arsenate	x	.05 As (A)	250 As (A)					3 As		1.7	389,000
Sodium Arsenite	x	0.05 As (A)	2 As (A)					3 As		1.87	v s
Sodium Azide			8 (A)					5	d	1.85	401,400
Sodium Bicarbonate	x		7500 (A15)	1060 (a)	4000 (A)			1 Na 10 HCO_3^-		2.159	69,000
Sodium Bifluoride	x		100 (a)					.05 F^-		2.08	s
Sodium Bisulfate			145 (A)					1 $SO_4^=$			
Sodium Bisulfite	x		240 (A18)					2 $SO_3^=$			
Sodium Borate	x	200(A)	240 (A15)					1	320	1.73	20,100
Sodium Bromate								1Na, 1Br		3.3	275,000
Sodium Butyl Mercaptide			1(D54)	.02(A)				.02			s
Sodium Carbonate	x		70(A15)	34(a)	1000(a)			10		2.53	20,000
Sodium Chlorate		200(A)	11,000(A)			12,000(a)		10	d	2.49	790,000

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Sodium Chloride			2,500(A15)	550(A)	700(A)			1Na, 1Cl	1413	2.16	357,000
Sodium Chlorite				200(a)				1Na, 1Cl	1413	2.17	357,000
Sodium Chromate	x	.05(A)	400(A15)					.003 Cr		2.7	87,300
Sodium Cyanide	x	.01 CN(A)	.05(A13)					.03 CN	1496		s
Sodium Dichloroisocyanurate	x	.01 CN(A)	.05(A)					.03 CN			
Sodium Dichromate	x	.05(A)	60(A15)					.003 Cr	d	2.52	2,380,000
Sodium Ferrocyanide	x	.01 CN(A)	2(A)					.03 CN			
Sodium Fluoride	x	1.0 F⁻(A)	2.6(A15)		200 F⁻(A)			.05 F⁻	1695	2.56	42,200
Sodium Formate	x		470(a9)				42(j)	10		1.92	440,000
Sodium Hydride*	NaOH + H_2								d	.92	d
Sodium Hydrosulfide	x		2(A18)					.05 S=	7500		v s
Sodium Hydrosulfite	x		.5(A)					2	d		259,000
Sodium Hydroxide	x		20(A18)	20(A)				.2	1390	2.13	420,000
Sodium Iodide	x		3.3(A)	.005(a)				.02		2.45	3.180,000
Sodium Methylate	x							15			
Sodium Nitrate			4000(A15)	450(A)				.01NO_3^-	d	2.26	730,000
Sodium Nitrite			7.5(A15)					.001NO_2^-	320	2.2	720,000
Sodium Oxlate	x		1350(A55)				33(j)	10		2.34	37,000

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Sodium Perborate	x		5(A)					1B	>100	>2.0	25,000
Sodium Perchlorate			.5(a)					1 Cl	d		
Sodium Permanganate	x		3KMNO4(A)					.2	d		deliq.
Sodium Peroxide	x		40 H_2O_2 (A)					.2	d	2.81	s
Sodium Phosphate		200(A)	720(A18)	200(A)				1			20,000
Sodium Picramate	x			.5(a)				10		Solid	d
Sodium-Potassium Alloy	$NaOH + KOH + H_2$										
Sodium Silicate	x		2400(A15)					.02			s
Sodium Sulfate			5000(A15)	300(A)	3000(A)			1	1000	2.6	47,600
Sodium Sulfide	x		2(A18)	.05(A)				.05		1.8	154,000
Sodium Sulfite			100(A18)					2	>100	1.54	328,000
Sodium Thiocyanate	x	.01CN(A)						.03CN	>100		1,393,000
Sodium Thiosulfate	x		24000(A15)					4			
Sodium Triphosphate			150(A15)					1			145,000
Strontium Arsenite	x		1(A)					.2 Sr 3 As			sl s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Strontium Chlorate	x		1100(A)					.2 Sr	d	3.2	1,749,000
Strontium Nitrate	x		7000(A)					.2 Sr .01 NO_3		2.9	401,000
Strontium Peroxide	x		40 H_2O_2(A)					.2 Sr .2 O^-	d	4.56	80
Strychnine		1(a)		2(a)		5(1)		1	270	1.35	100
Styrene (monomer)			25(H)	.1(I)		5000(P)		1000	146	.9	v sl s
Sorbitol								2			s
Succinic Acid	x		1000(A)					10	235	1.56	68,000
Sulfolane			1-100(BAS-3)								
Sulfur (Dissolved or Colloidal)		5(A)	1,600(A31)	.1(A)				1	444	2	i
Sulfur Chloride →	HCl + H_2SO_4								59	1.6	d
Sulfur Dioxide			.5(A)					2	-10	2.9 g/1	s
Sulfur Hexafluoride	x	1 F-(A)						.05 F	-63.8	6.5	v sl s
Sulfuric Acid	x		10(A18)					1	330	1.8	-
Sulfur Trioxide →	H_2SO_4								44.8	2.75	d
Sulfuryl Chloride →	H_2SO_4 + Cl_2							.1	69.1	1.6	d

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Sulfuryl Fluoride	HF + H_2SO_4								-52	3.72	d
Tannic Acid	x		37(E)	10(A11)	4(A)			.1			s
Tartaric Acid	x			100(A11)				10		1.6	v s
Tertiary Butyl Isopropyl Benzene											i
Tetradecanol (Sol <CC									263	.83	200
1-Tetradecene									246	.775	i
Tetraethylene Glycol			1000-10,000 (NAS-1)				0(10 days) (b)	2	275	1.01	∞
Tetraethyl Lead (and Mixes)		.05(A57)	.2(A56)		50Pb(A5)			.05	200	1.6	i
Tetraethyl Pyrophosphate											
Tetrafluoroethylene									-78.4		i
Tetrahydrofuran									66		v s
Tetrahydronaphthalene			1-100(NAS-3)					1000	207	.9	i
Tetramethyl Lead		.05(A)			50Pb(A5)			.05	110	1.9	i
Tetrapropylene			1000-10,000 (NAS-1)					1000			

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/l)	Fish Toxicity Critical Concentration (mg/l)	Aesthetic Critical Concentration (mg/l)	Plant Toxicity Critical Concentration (mg/l)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/l)	Boiling Point (°C)	Specific Gravity	Solubility (mg/l)
Thallium Sulfate	x	.05(a)			100(A)			1	d	6.7	48,700
Thionyl Chloride	SO_2 + HCl								78.8	1.65	d
Thiophene			27(a)					4	84	1.06	
Thiophenol				.02(A58)				1	169.5	1.59	i
Thiophosphoryl Chloride	→ $H_3PO_4 + SO_2 + H_2$								125	1.6	d
Thorium (metal)									>3000	11.2	i
Thorium Nitrate	x		18(A)					.5 Th .01 NO_3	d		v s
Tin Tetrachloride (stannic chloride)	x		125(A)					2 Sn	50	2.2	s
Titanium Sulfate								.01 Ti			i
Titanium Tetrachloride	x		5 Daphina(a)		10(a)			.01 Ti	136	1.7	sl s
Toluene		50(K)	50(A59)			7000(K)	0(j)	30	110	.86	470
Toluene Diisocyanate	x	.01 CN(A)				5800(M)		.03 CN			
Toluidine			100(A)	2			45(j)	1	199	1	15,000
Triamylamine				.5(A)				.5	232	.8	
Tributylamine			40(b)	.5(A)				.5	214	.78	sl s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Trichlorobenzene			1-100(NAS-3)					10	213	1.5	25
Trichloroethane			75(A)					10	74	1.3	i
Trichloroethylene			55(A)			5200(H)		10	87	1.4	1000
Trichlorofluoromethane			200(A)						24.1	1.494	i
Trichlorofluorosilane *	Cl_2+HCl +	SiO_2									
Trichloroisocyanuric Acid	F	.01 CN(A)						.01 CN			
Trichlorophenol				.001(A)				.1	253	1.5	sl s
Trichlorosilane	Cl_2+HCl +	SiO_2							33	1.34	d
Tridecanol									263	.82	i
Triethanolamine			20(a)			9000(t)	0(10 days) (B38)	-100	90	.72	15,000
Triethylamine			80(All)			460(S)		1	90	.72	s
Triethyl Benzene			100-1000(NAS-2)					50	218	.86	i
Triethylene Glycol			1000-10,000(NAS-1)				1.4(D)	2	280	1.1	∞
Triethylene Tetramine				.5(A)				-10	278	.9	
Trimethylamine			250(a)	.1(I)				10	3.5	.66	v s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Trimethylchlorosilane →	Chloromethane	+Ethane	+ S_iO_2								d
Trinitrobenzene			10 (A)					5			i
Trinitrobenzoic Acid	x		10 (A)					5	228		20,500
Trinitroresorcinol								5	180	1.8	6,000
Tripropylene			1000-10,000(NAS-1)					10			
Turpentine			1 (a)					.005	150	.85	
Undecanol									130	.8	i
1-Undecene									193	.77	i
Uranyl Nitrate	x	.5 U (A)						.005 U	d	2.8	1,700,000
Urea (plus salts)			16,000 (A9)					10	>100	1.3	780,000
Unsymmetrical Dimethyl Hydrazine			100 (A)					10	63	.7	s
Valeraldehyde			100-1000(NAS-2)					5	103	.82	sl s
Vanadium Oxytrichloride →	V_2O_5+HCl										
Vanadium Pentoxide	x				26 V (A)			.2V	126	1.8	s d
Vanadium Tetrachloride →	V_2O_5+HCl								148	1.8	s d

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD$_5$	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Vinyl Acetate			25(H)	30(A)							
Vinyl Chloride (non persistent)								15	73	.934	
Vinyl Ether									-13.9	.9/1	sl s
Vinyl Fluoride								1000	39	.77	i
Vinylidene Chloride			100-1000(NAS-2)						-51		i
Vinyl Methyl Ether		.2(O)						10	31.6	1.2	
Vinyl Toluene			1-100(NAS-3)					10	6	.75	
Vinyl Trichlorosilane →	Cl$_2$ + Vinyl Chloride + SiO$_2$							10	170	.89	
Waxes											d
Xylenes			10(A60)	.3(A50)	1000(A)	4300(a5)				>1	i
Xylenols			5(A40)	.001(A)			0(j)	10 m	144	.88	i
Xylyl Bromide							31(j)	1	211	1.1	s
Zinc Acetate	x			5 Zn(A)					220	1.3	i
Zinc Ammonium Nitrate	x			5 Zn(A)				.05 Zn	>100	1.84	300,000
Zinc Arsenate	x			5 Zn(A)				.05 Zn			
Zinc Arsenite	x			5 Zn(A)				.05 Zn	d	3.3	i
Zinc Chlorate	x			5 Zn(A)				.05 Zn			i
								.05 Zn	d	2.5	2,620,000

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Zinc Chloride	x		1(A)	5 Zn(A)		75LDIV(r)		.05 Zn	732	2.91	4,320,000
Zinc Cyanide	x	.01 CN(A)		5 Zn(A)				.05 Zn/ .03 CN	d		5
Zinc Ethyl +	Ethane +	Zn(OH)$_2$									d
Zinc Nitrate	x		5.7(A)	5 Zn(A)				.05 Zn			3,273,000
Zinc Oxide	x		2MnO$_4$(A)	5 Zn(A)				.05 Zn			
Zinc Permanganate	x	5 Zn(A)						.05 Zn	d	2.47	v s
Zinc Peroxide	x	5 Zn(A)	40 H$_2$O$_2$(A)	5 Zn(A)				.05 Zn/ MnO$_4^-$		1.5	22
Zinc Sulfate	x		3(A)	5 Zn(A)	10(A)			.05 Zn	>100	3.54	s
Zirconium (metal)	x							.3 Zr	2900	6.4	i
Zirconium Picramate	x			1(A)		1000(A)		.3 Zr			
FUNGICIDES											
Captan			.30(A)			10,000(A)		.3			i
Copper Naphthenate	x							.02 Cu			s
Dichloronaphthoquinone			.07(A)			1500(A)					.1

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Ferbam			1.0(A) G			4000(A)		1000			i
Mercury Fungicides		.005 Hg (A)						.5 Hg			
Nabam			.5(a61)			395(a)		1000			
Pentachlorophenol			.2(A40)			78(a)		.1			i
Thiram			.79(a)			350(a)		.5			i
ZDG			.008(A)					.05Zn			
HERBICIDES											
Ammonium Sulfamate			10(A)			3,900(a)		5 SO_4			v s
2,4-D Acid			100(A62)	.01(a)	20(A)	500(A)		2			35,000
2,4-D, Esters, Salt			Ester - 1(A) Salt - 250(A)	.01(a)	3(a)	500(A)		2			s
CMU		180(a)	40(A)		8(A)	3500(a)		5			s
Dalapon			340(A)		.35(A)	6590(A)		5			s
Diuron			5(A61)			3400(a)					42
DNBP								1000			
DNBP (ammonium salt				.5 NH_4^+(A)				.2 NH_4			
Endothal			140(A61)		100(A)	35(a)		5			s

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
IPC			60 (A)			1000 (a)		10			
MCP			15 (M26)					10			
Phenyl Mercuric Acetate								.5 Hg			
Sesone						640 (A)		1000			
Silvex (2,4,5-T)			1.0 (A63)			650 (a)		.1			s s
TBA			150 (2,3,5) (a) 1500 (2,3,6) (a)			300 (A)		50			
TCA			1000 (A)			3,300 (A)		50			s
2,4,5-T (Acid, Esters, Salts)			10 (A)			300 (a)		.1			
INSECTICIDES, FUMIGANTS AND RODENTICIDES											
Aldrin-Toxaphene Group			.023 (f64)			40 (A)		.5			i
Benzene Hexachloride (Lindane)			.018 (A65)	.02 (a)		125 (A)		100			10
Chlordane			.01 (A66)			340 (A)					i
Chlorthion			.0045 (A66)			550 (A)		1 PO_4			i

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
DDD (TDE or Rhothane)			.013(A40)			3400(A)		.001			1
DDT			.0023(A67)	.2(a)		250(a)		.001			.2 Colloidal
Diazinon			.004(A)			100(A)		1 PO_4			
Dicapthon			2(a61)			460(A)		1 PO_4			
Dieldrin		.1 /5 gm(K)	.003(A68)			40(A5)		.5			1
Dipterex			50(A65)			400(A)		1 PO_4			130,000
Dibromochloro-propene								10			
Endrin			.001(A68)			10(A)					1
Guthion			.01(A69)			11(A)		1 PO_4			33
Heptachlor			.019(B70)			90(A)					1
Isodrin			.0015(A)			7(A)		.5			
Kelthane			.5(a)			575(A)					
Malathion			.02(A71)			1000(A)		1 PO_4			45
Metasystox®			5(a)			40(A)		1 PO_4			sl s
Methoxychlor			.025(A72)			5000(A)					sl s
Methyl Parathion		150 mg(a)	.04(A14)			3(A)		1000			
Nicotine		>10(A)	8(A)			55(A)		20			
Ovotran			10(a)			2000(a)		5			1

TABLE B-1. (Continued)

Hazardous Material	Adequate Response Available	Human Toxicity Critical Concentration (mg/1)	Fish Toxicity Critical Concentration (mg/1)	Aesthetic Critical Concentration (mg/1)	Plant Toxicity Critical Concentration (mg/1)	Rat Toxicity (mg/Kg body wt.)	% Theoretical BOD_5	Field Detection Limit (mg/1)	Boiling Point (°C)	Specific Gravity	Solubility (mg/1)
Phosdrin			.017(A)			6(A)		1 PO_4			v s
Pyrethrum			2(A)			200(A)					
Rotenone			.022(A11)	.018(A)		132(A)					17
Schradan			120(A)		100?(A)	9(A)		1 PO_4			
Sevin			5(A73)			500(A)		5			1000
Simazine			6.6(A)			>5000(a)		5			i
Sulfoxide			.75(a)	.091(a)							
Systox			3.6(A66)			2.5(A)		1 PO_4			i
TEPP (HETP)		/50 mg(A)	1.0(A65)			1.2(A)		1 PO_4			v s
Thiodan			.01(a)			90(A)					
Toxaphene			.005(A67)	.005(a)		69(A)		.5			1.5
OTHERS											
Fenuron			500 (A60)			7500(a)					2900
Kuron			1.23(A)			500 (a)					i
Omazene			.83(A6C)					.02Cu			
Perthane			.1(a)			8200 (A)					
Tedion			.5(a)			14,700 (a)		.5			
Vapam			1(a)			800 (a)		5			s
Parathion		/100 mg(A)	.001(G74)			2(A)		1000			20

TABLE B-2. Critical Concentration Footnotes

1 = djK
2 = j
3 = bDE
4 = ABDeK
5 = K
6 = k
7 = BcDejK
8 = jK
9 = bj
10 = DFK
11 = b
12 = cbDFK
13 = DF
14 = f
15 = E
16 = dfK
17 = de
18 = e
19 = BdeK
20 = ajK
21 = Aj
22 = bcjk
23 = cj
24 = BDEFHjK
25 = IK
26 = A
27 = BcDEj
28 = HjK
29 = D
30 = dEK
31 = eK
32 = DfH
33 = BCDEFHjK
34 = IjK
35 = beHj
36 = a
37 = bDEF
38 = Dj
39 = bcdef
40 = B
41 = bcK
42 = ADC
43 = bjk
44 = abEFK
45 = c
46 = d
47 = bcDE
48 = bcj
49 = BDEfK
50 = Ij
51 = BOD
52 = be
53 = BcdEfj
54 = af
55 = bde
56 = DK
57 = fk
58 = I
59 = bcDEfHjK
60 = bHjK
61 = M
62 = bG
63 = GM
64 = ABM
65 = bfM
66 = bf
67 = BDFGM
68 = BfGM
69 = bM
70 = Af
71 = bDFGM
72 = fG
73 = bGM
74 = ABFM

TABLE B-3. Critical Concentration References

aA McKee, J. E., H. W. Wolf, "Water Quality Criteria" 2nd Ed, Resources Agency of California 1963.

bB Ryckman, D. W., et al., "Behavior of Organic Chemicals in the Aquatic Environment," Part 1, Manufacturing Chemists Association, Washington D.C., Summer 1966.

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APPENDIX C

WATER USE CLASSIFICATION SYSTEM TABLES

Table C-1 outlines some of the principle criteria that can be used to formulate a hazardous material classification system. Table C-2 lists and characterizes 30 of the major systems presently in use. Two possible functional outputs of the Water Use Classification System are given in Tables C-3 and C-4. Table C-3 is derived from the data in Appendix B. Each compound is associated with a rating number for each quality parameter for which a critical concentration value was listed in Appendix B. The numbers indicate the following:

1 - The compound is not detectable by field detection methods at or below the critical concentration nor are adequate response procedures available for neutralization of the spill.

2 - The compound is not detectable by field detection methods at or below the critical concentration but adequate response procedures are available for neutralization of the spill.

3 - The compound is detectable in the field at or below the critical concentration but adequate response procedures are not available for neutralization of the spill.

4 - The compound is detectable in the field at or below the critical concentration and adequate response procedures are available for neutralization of the spill.

Table C-4 is derived from Table C-3. It lists the compounds categorized under each of the four numerical classifications for each water quality parameter. Hence, Table C-3 is listed by compound while Table C-4 is listed by water quality parameter.

TABLE C-1. Possible Classification System Criteria

1. Identification of Hazardous Material
   - A. Name
   - B. Chemical Class
   - C. Physical and chemical properties
   - D. Toxicology
2. Specification of Nature of Hazard
   - A. Overall effect
   - B. By nature of attack by hazardous material
   - C. By nature of possible accident
   - D. By chemical and physical effect
   - E. By hazard class
3. Specification of Degree of Hazard
4. Specification of Mode of Transport
   - A. Truck
   - B. Rail
   - C. Air
   - D. Water
   - E. Pipe
   - F. Combination of the above
5. Specification of Handling Activity Required or Expected
   - A. Transport
   - B. Store
   - C. Use en route
   - D. Combination
6. Specification of Expected Environmental Stresses in Handling
   - A. Thermal
   - B. Mechanical shock or vibration
   - C. Abrasion
   - D. Compression
   - E. Impact
   - F. Puncture
   - G. Pressure
   - H. Moisture
   - I. Combination of the above

TABLE C-1. (continued)

7. Specification of Corrective Actions to be Taken in Case of Accident
8. Specification of Exemptions and Exceptions to Above
9. Compatibility with Other Substances
10. Detectability
11. Availability of Techniques for Neutralization of a Spill

TABLE C-2. Characteristics of Present Classification Systems (from Booz-Allen & Hamilton)(3)

No.	System	Modal Appli-cation	Multiple Hazard	Orientation	Storage & Shipping Container Specified	Degree of Hazard	Corrective Action	Transport Quantity Limitation	Compatibility	Mechanism of Hazard	Odor/ Appearance Indicated
1	Title 49 DOT	RR Truck Air	No	Gov't. Regulations	Yes	No	No	Yes	By class	No	No
2	Title 46 DOT/CG	Water	No	Gov't. Regulations	Yes	No	Limited	Capacity of outside containers given	Limited, by commodity	No	Limited
3	Dockets HN-7, HN-8 Proposed DOT	All	Only for poisons & radio-actives	Gov't. Regulations	Yes	No	Limited		By class	NA	No
4	AAR Tariff 23 Amer.Assoc. Railroads	RR Truck Air	No	Tariff	Yes	No	No		By class	No	No
5	AAR Tariff 22 Amer.Assoc. Railroads	Water	No	Tariff	Yes	No	Limited		Limited, by commodity	No	Limited
6	ATA Tariff 14 American Trucking Assoc.	Truck	No	Tariff	Yes	No	No		By class	No	No
7	NFPA, Fire Protec. Guide Nat'l Fire Prot.Assoc.	All	Yes	Insurance	Limited	Yes (4 grades)	Yes	No	No	Yes	Yes
8	Penn Central General Notice 225	RR	No	Industry Regulations	Yes	No	No	Yes	No	No	No

TABLE C-2. (continued)

No.	System	Modal Application	Multiple Hazard	Orientation	Storage & Shipping Container Specified	Degree of Hazard	Corrective Action	Transport Quantity Limitation	Compatibility	Mechanism of Hazard	Odor/ Appearance Indicated
9	IATA Intern. Air Transp. Assoc.	Air	No	International Regulations	Yes	No	No	Yes	Limited	No	No
10	Nat'l Paint, Varnish & Lacquer Assoc.	All	Yes	Labeling Guide	No	No	Limited	No	No	Limited	No
11	NAS/CG Public 1465	Water	Yes	Compatibility quide hazard evaluation, bulk water transport	No	Yes	No	No	Yes	Yes	No
12	American Insurance Assoc.	All	Yes	Insurance	Limited	Yes	Yes	No	No	No	Yes
13	National Safety Council - Chemical Safety Guide	All	Limited	Safety rules for hazard identific. and control	No	Yes	Yes	No	No	Yes	Limited
14	United Nations	All	Yes	International Regulations	Yes	No	No	Yes	Limited	No	No
15	CG-388 Chemical Data Guide, Coast Guard	Water	No	Guide for bulk water shipment	No	Yes	Yes	No	Limited	Yes	Yes
16	Dow Fire & Explosion Index (AICHE)		Yes (Index value)	Industry Guide for fire & explosion prevention	No	Yes (Index value)	No	No	Yes (Index value)	Yes (Index value)	Limited

TABLE C-2. (continued)

No.	System	Modal Appli- cation	Multiple Hazard	Orientation	Storage & Shipping Container Specified	Degree of Hazard	Corrective Action	Transport Quantity Limitation	Compatibility	Mechanism of Hazard	Odor/ Appearance Indicated
17	NAS/NRC Arlie House Conference	All	Yes	Proposed classification systems	No	Yes	No	No	No	Yes	No
18	MCA, Mfg. Chem.Assoc Chem-card system	All	Yes	Product label guide	No	No	Yes	No	No	Yes	Yes
19	MCA-Manual L-1, Mfg. Chem.Assoc. Guide to Precaut. Label. 1969		Limited	Labeling, storage, handling & use	Not specified by commodity	No	Yes	No	No	Yes	No
20	NAS/CG Compatibility chart	All	Yes	Chemical compatibility of binary systems	No	No	No	No	Yes	No	No
21	U.S. Navy NAVSUP Public 4500	All	No	Service guide for supply system	No	No	No	No	Yes		No
22	NACA Nat'l Agric. Chem.Assoc.	All	No	Safety guide Industry	Yes	No	Yes	No	No	No	No
23	Amer. Petroleum Institute Bulletin 2511	All	Limited	Labeling Guide	No	No	Limited	No	No	No	No
24	Port of N.Y. Authority	Truck	No	Tunnel & Bridge Regulations	No	No	No	Yes	No	No	

TABLE C-2. (continued)

No.	System	Modal Appli-cation	Multiple Hazard	Orientation	Storage & Shipping Container Specified	Degree of Hazard	Corrective Action	Transport Quantity Limitation	Compatibility	Mechanism of Hazard	Odor/ Appearance Indicated
25	I. Sax Dangerous Prop. of Indust.Mat.	All	Limited	Reference Manual	No	Yes	Yes	No	Yes	Yes	Yes
26	SOLA - Safety of Life at Sea, Intern. Convention 1969	All	Yes	International Regulations	Yes	No	No	No	No	No	Limited
27	USA Standards Institute-Radioactive Waste Categories	All	No	Proposed definition of radioactive waste categories	No	Limited	No	No	No	No	No
28	IMC Code - Internat. Maritime Commission (IMCO)	Water	Yes	International Regulations	Yes	No			Limited	No	
29	ASTM/CG American Soc. for Testing Materials	All	Yes	Hazard Regulation	No	Yes			No		
30	NAS/ Sulfur Study	Water	Yes	Hazard Evaluation	No	Yes	No	No	Yes	Yes	No

TABLE C-3. Water Use Classification System by Compound

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Abietic Acid		4		
Acetaldehyde		3		
Acetaldol	3	3		
Acetamide		3		
Acetic Acid		4	4	
Acetic Anhydride		4		
Acetone		3	1	
Acetone Cyanhydrin	2	4		
Acetronitrite	2	4		
Acetopheonone			1	
Acetyl Benzoyl Peroxide		3		
Acetyl Chloride		→ HCl + CH_3OOH		
Acetylene		1		
Acetylene Dichloride				
Acetyl Peroxide		3		
Acridine		1		
Acrolein		3		3
Acrylic Acid		4		
Acrylonitrile	2	4	2	
Adipic Acid		4		
Adiponitrile		4		
Alanin				
Alkyl Aryl Sulphonate		3	1	
Allyl Acetate				
Allyl Alcohol		3		
Allylamine			1	
Allym Bromide				
Allyl Chloride		3	3	
Allylchloroformate		→ Allyl Alcohol + chloroformic acid		
Allyldine Diacetate				
Allyl Trichlorosilane		→ $SiO_2 + Cl_2$ + propylene or allyl chloride		
Aluminum Ammonium Sulfate		4		4
Aluminum Chloride		4		4
Aluminum Fluoride				4
Aluminum Nitrate		4		4
Aluminum Oxide				4
Aluminum Sulfate		4		4
Aluminum Triethyl		→ $Al(OH)_3 + C_2H_6$		
N-Aminoethyl Ethanolamine		3	3	
Ammonia, Anhyd, 28% Aq.	3	3	3	

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Ammonium Acetate		3	3	
Ammonium Arsenate		4	3	
Ammonium Carbonate		4	3	
Ammonium Chloride		3	3	
Ammonium Chromate		4	3	
Ammonium Dichromate		4	3	
Ammonium Ferrocyanide	2	2	3	
Ammonium Fluoride		4	3	
Ammonium Hydroxide		4	3	
Ammonium Molybdate		4	3	
Ammonium Nitrate		3	3	
Ammonium Perchlorate			3	
Ammonium Permanganate		4	3	
Ammonium Persulfate		4	3	
Ammonium Picrate			3	
Ammonium Sulfate		3	3	
Ammonium Sulfide		4	1	
Ammonium Sulfite		3	3	
Ammonium Thiocyanate		4	3	
Amyl Acetate		3	3	
Amyl Alcohol		3		
Amyl Amine		3		
Amyl Bromide		3		
Amyl Mercaptan			1	
Amyl Nitrite →	Decomposes			
Amyl Trichlorosilane →	$SiO_2 + Cl_2$ + pentane			
Aniline	3	3	3	
Anisoyl Chloride →	$CH_3OC_6H_4COOH$			
Antimony Pentachloride →	Antimony trichloride + Cl_2			
Antimony Pentafluoride				
Antimony Trichloride				
Antimony Pentasulfide				
Antimony Potassium Tartrate		4		
Antimony Trichloride		4		
Antimony Trifluoride		4		
Antimony Trioxide		3		
Arsenic Compounds	2	2		2
Barium Acetate	4	4		
Barium Carbonate	4	4		
Barium Chlorate				
Barium Chloride		4		
Barium Cyanide	2			
Barium Fluoride		4		
Barium Nitrate		4		
Barium Perchlorate				

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Barium Permanganate		4		
Barium Peroxide		4		
Barium Sulfide				
Benzaldehyde		3	1	
Benzanine Sulfonic Acid		4		
Benzene		3	3	
Benzine Phosphorus Dichloride		1		
Benzoic Acid		4	2	
Benzonitrile		4		
Benzoyl Chloride →	HCl + Benzoic Acid			
Benzoyl Peroxide		3		
Benzyl Alcohol		3		
Benzylamine		3		
Benzyl Bromide		1		
Benzyl Chloride		1		
Benzyl Chloroformate →	Chloroformic acid + Phenol			
Beryllium Dust		3		3
Boric Acid		4		
Boron Hydride →	$H_3BO_3 + H_2$			
Boron Trichloride →	$H_3BO_3 + HCl$			
Boron Trifluoride		4		
Brombenzyl Cyanide				
Bromine		3		
Bromine Pentafluoride →	HF + HBr			
Bromine Trifluoride →	HF + HBr			
Bromoacetone				
Bromomethane				
Butadiene (inhibited)		1		
Butane		3		
Butene				
Butyl Acetate		3		
Acrylate		3		
Butyl Alcohol		3	1	
Butyl Aldehyde				
Butyl Amine		3	1	
Butyl Hydroperoxide		3		
Butyl Lithium →	LiOH + Butane			
Butyl Mercaptan			1	
Butyraldehyde		3		
Butyric Acid		4		4
Cadmium Chloride	4	4		4
Cadmium Nitrate	4	4		4
Cadmium Sulfate	4	4		4
Calcium →	$Ca(OH_2) + H_2$			
Calcium Arsenate	2	2		2
Calcium Carbide →	$Ca(OH)_2 + C_2H_2$			
Calcium Carbonate	4	4	4	

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Calcium Chloride	4	4	4	4
Calcium Cyanide	→ $Ca(OH)_2$ + HCN			
Calcium Fluoride	4	4		
Calcium Fluosilicate		4		
Calcium Hydroxide	4	4		
Calcium Hypochlorite	→ $Ca(OH)_2$ + Cl_2			
Calcium Nitrate	4	4		
Calcium Phosphate	4	4		
Calcium Sulfate	4	4	4	
Camphor		3	1	
Carbon Disulfide	1	3	1	
Carbon Monoxide		1		
Carbon Tetrachloride	1	3	1	
Caustic Potash		4		4
Caustic Soda		4		4
Cetyl Alcohol-insol				
Chenopodium Oil		3	3	
Chloramine-T		1		
Chlorine		1	3	3
Chlorine Trifluoride	→ HCl + HF			
Chlorobenzene		1		
Chloroform	1	1		
Chlorohydrin		3		
Chloroisocyanuric Acid	2			
Chloromethane	3			
Chlorophenol		3	3	
Chloroprene		3		
Chlorosulfonic Acid	→ H_2S + HCl			
Chromic Acid	4	4		4
Chromium Sulfate	4	4		4
Chromyl Chloride	→ H_2CrOH_4 + HCl			
Citric Acid		3		
Cobalt Chloride		4		4
Cobalt Nitrate		4		4
Cobalt Sulfate				4
Copper Acetoarsenite	3			
Copper Chloride	4	4	4	
Copper Nitrate	4	4	4	
Copper Sulfate		4		
Cresol		3	1	
Cresotic Acid			2	
Crotonaldehyde		1		
Cumene		1		
Cumine Hydroperoxide		3		
Cupric Chrome Gluconate		3		

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Cyanogen Chloride		3		
Cyclohexane		1		
Cyclohexane Carboxylic Acid (Naphthenic Acid)		3		
Cyclohexanol		3		
Cyclohexanone		3		
Cyclohexylamine			1	
Decaborane	→ $B_2O_3 + H_2$			
Decaldehyde				
Decene				
Decyl Alcohol		3		
Detergents		3		
Diallyl Phthalate		3		
Diamyl Amine		3		
Diborane	→ $H_3BO_3 + H_2$			
Dibutyl Peroxide		3		
Dibutyl Phthalate		3		
Dibutyl Thiourea		3		
Dichlorobenzene		4		
Dichlorobutane		3		
Dichlorodifluoromethane				
Dichloroethylene		3		
Dichloroethyl Ether	1	3		
Dichloroisopropyl Ether			1	
Dichlorophenol			3	
Dichloropropane		3		
Dicyclopentadiene		3		
Diethanolamine		3		
Diethyl Aluminum Chloride				
Diethyl Benzene		1		
Diethyl Dichlorosilane				
Diethylene Glycol		3		
Diethylene Glycol Monoether		3		
Diethylenetriamine		3	1	
Diisobutyl Ketone		1		
Diisobutylene		3		
Diisopropanolamine		1		
Diisopropyl Peroxdicarbonate				
Dimethylamine		1	1	1
Dimethyldioxane		1	1	
Dimethyl Ether	1			
Dimethyl Formamide				
Dimethyl Hydrazine		3		
Dimethyl Sulfate	→ H_2SO_4 +	CH_3OH		
Dimethyl Sulfide				
Dinitro Aniline				

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Dinitrobenzene		3		
Dinitrocresols		3		
Dinitrophenol		3	1	
Dinitrotoluene		1		
Dioxane	1			
Dipentene		1		
Diphenylaminechloroarsine				
Dipropylene Glycol		3		
Divinyl Benzene				
Dodecanol				
Dodecene				
Dodecyl Benzene		3		
Dodecyl Mercaptan			1	
Divinyl Benzene				
Dyes (all)		3	3	
Epichlorohydrin		1		
Ethanolamine		3		
Ethers (all)	1			
Ethoxy Triglycol		3		
Ethyl Acetate		3		
Ethyl Acrylate		3		
Ethyl Alcohol	3	3		
Ethylamine		3	1	
Ethyl Benzene		1		
Ethyl Chloride		3		
Ethylene		3		
Ethylene Cyanohydrin		1		
Ethylene Diamine	3	3	1	
EDTA		3		
Ethylene Dichloride		1		
Ethylene Glycol		3		
Ethylene Glycol mono-other		3		
Ethylene Acetate		3		
Ethylene Oxide		3		
Ethylenimine		3		
Ethyl Ether	1			
Ethyl Formate				
2-Ethyl Hexanol-1	1			
2-Ethylhexyl Acrylate		3		
Ethyl Methyl Ketone				
Ethyl Phthalate		1		
3-Ethyl Propyl		3		
2-Ethyl Acrolein		3		
Fatty acids	2	2		

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Ferric Chloride		4		
Ferric Oxide		4		
Ferric Potassium Sulfate		4		
Ferric Sulfate		4	4	
Ferrous Chloride		4	4	
Ferrous Sulfate		4	4	
Ferrous Oxide		4		
Ferrous Sulfite		4		
Fluorine	→ $HF + O_2$			
Fluosulfonic Acid	→ $H_2SO_4 + HF$			
Formaldehyde		3	3	
Formic Acid		4		
Fumaric Acid		4		
Furfural		3	3	
Furfuryl Alcohol		1		
Gallic Acid		4		
Glycerin		3		
Glycol Diacetate		3		
Glyoxal		3		
Guaiacol		3	1	
Hafnium (metal)				
Heptane		1		
Heptanol		3		
Heptene (Isomers)		3		
Hexaethyl Tetraphosphate				
Hexafluorophosphoric acid	→ $HPO_2F_2 + 4HF$			
Hexafluoropropylene				
Hexamethylene Diamine			1	
Hexane		3		
Hexanol		3		
1-Hexene				
Hexylene Glycol		3		
Hexyl Trichlorosilane	→ S_iO_2 + Chlorohexane + Cl_2			
Hydrazine		3		
Hydrochloric Acid		4	4	
Hydrofluoric Acid	4	4		
Hydrofluosilic acid				
Hydrogen				
Hydrogen Bromide	4			
Hydrogen Chloride		4	4	
Hydrogen Cyanide	2	2	2	4
Hydrogen Peroxide		4	4	
Hydrogen Sulfide		3	3	
Hydroquinone		3		

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Hydroxylamine		3	3	
Hypochlorite		3		
Hypoiodite		3		
Iodacetic Acid		4		
Iodine		3		
Iodine Monochloride	→ $HIO + HOCl$			
Isobutene				
Isobutyl Acetate		3		
Isobutyraldehyde		3		
Isodecaldehyde		3		
Isodecanol		3		
Isooctane				
Isooctanol		1		
Isooctene				
Isooctyl Aldehyde		3		
Isopentane				
Isophorone		1		
Isoprene	1	3	1	
Isopropyl Acetate		3		
Isopropyl Alcohol		3		
Isopropylamine		3	1	
Isopropyl Ether		3		
Isopropyl Formate				
Isopropyl Mercaptan			3	
Isopropyl Percarbonate				
Lactic Acid		4		
Lactonitrile	2	4		
Lauroyl Peroxide		3		
Lead Acetate	4	4	4	
Lead Arsenate	4	4		4
Lead Arsenite	4	4		4
Lead Chloride	4	4		4
Lead Cyanide	2			4
Lead Nitrate	4	4		4
Lead Oxide				
Lead Sulfate	4	4		4
Lead Sulfocyanate	2			4
Lithium (metal)	→ $LiOH + H_2$			
Lithium Aluminum Hydride	→ $H_2 + Al(OH)_3$			
Lithium Amide	→ $LiOH + NH_3$			
Lithium Carbonate	4	4		
Lithium Chloride	4	4		
Lithium Ferro Silicon	4			
Lithium Fluoride	4	4		

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Lithium Hydride	→ LiOH + H_2			
Lithium Hydroxide	4			
Lithium Hypochlorite Compounds	4	2		
Lithium Peroxide	4	4		
Lithium Silicon	4			
Lithium Sulfate	4			
Magnesium (metal)		→ Mg $(OH)_2$ + H_2		
Magnesium Arsenate (i)				
Magnesium Chloride	4	4	4	4
Magnesium Fluoride		4		
Magnesium Nitrate		4	4	
Magnesium Perchlorate				
Magnesium Peroxide				
Magnesium Silicofluoride		4		
Magnesium Sulfate		4	4	
Maleic Anhydride		4		
Manganese Chloride		4		
Manganese Nitrate		4		
Manganese Sulfate		4		4
Mercaptans (dodecyl)		3	3	
Mercaptoethanol			3	
Mercuric Ammonium Chloride	1			
Mercuric Benzoate	1	3		
Mercuric Bromide	1			
Mercuric Chloride	1	3		
Mercuric Cyanide	1	3		
Mercuric Iodide	1			
Mercuric Nitrate	1	3		
Mercuric Oleate	1	3		
Mercuric Oxide	1			
Mercuric Oxycyanide	1	3		
Mercuric Potassium Cyanide	1			
Mercuric Salicylate	1	3		
Mercuric Sulfate and Subsulfate	→ HgO + H_2SO_4			
Mercuric Sulfo Cyanate	1			
Mercurous Bromide	1			
Mercurous Chloride	1			
Mercurous Gluconate	1			
Mercurous Iodide	1			
Mercurous Nitrate		→ H_2NO_3 + HgO		
Mercurous Sulfate	1			
Mercury	1	1		

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Mercury Acetate	1			
Mesitylene			1	
Mesityl Oxide		1		
Methane				
Methyl Acetate				
Methyl Acetylene				
Methyl Acrylate		3		
Methyl Alcohol	1	3		
Methylamines		3	1	
Methyl Amyl Acetate		3		
Methyl Amyl Alcohol		3		
Methyl Bromide		3		
Methyl Butyraldehyde		4		
Methyl Chloride	3	3		
Methyl Chlorofromate →	CH_3OH + Chloroformic Acid			
Methyl Dichlorosilane →	$S_iO_2 + CH_4 + Cl_2$			
Methylene Chloride		3		
Methyl Ether				
Methyl 5-Ethyl Pyridine		1	1	
Methyl Formal		3		
Methyl Hydrazine		3		
Methyl Isobutyl Carbinol				
Methyl Isobutyl Ketone		3		
Methyl Mercaptan		3	3	
Methyl Methacrylate		3	3	
Methylnaphthoquinone		3		
Methyl Salicylate			3	
Mineral Spirits #10		3		
Monobromotrichloromethane				
Monochloracetic Acid				
Monochlorodifluoromethane		3		
Monochlorofluoroethane				
Monoethanolamine		3		
Monoethylamine		3		
Monofluorophosphoric Acid	4			
Monoisopropanolamine		3	1	
Monomethyl Hydrazine		3		
Morpholine		1		
Motor Fuel Antiknock Compound	3			
Naphthalic Acid		4		
Naphthol		1	1	
Naphthalene		3	1	
Naphthoquinone		3		

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Nickel Ammonium Sulfate	2	2		2
Nickel Carbonyl		2		2
Nickel Chloride	2	4		2
Nickel Cyanide				4
Nickel Nitrate	4	2		2
Nickel Sulfate	2	4		2
Nicotine Hydrochloride				
Nicotine Salicylate Tartate and Sulfate		1		
Nitrating Acid (combination of nitric and sulfuric acids)				
Nitric Acid	4	4		
Nitroaniline		3		
Nitrobenzene		3	1	
Nitrochloro Benzene				
Nitroethane				
Nitrohydrochloric Acid →	$HCl + HNO_3$			
Nitromethane				
Nitrophenol		3	1	
Nitropropane		3		
Nitrosylchloride →	$NO_2 + HCl$			
Nitrotoluene		3		
Nitrous Oxide (Tetraoxide) →	H_2NO_3			
Nonane		3		
Nonene		3		
Nonyl Alcohol		3		
Nonyl Phenol			1	
Octodecyl Trichlorosilan →	Cl_2 + Chlorooctodecane (i) + SiO_2			
Octyl Alcohols		3	1	
Octyl Trichlorosilane →	Cl_2 + Chlorooctane + SiO_2			
Oil of Vitriol		$= H_2SO_4$		
Oleic Acid	2			
Oleum	$= H_2SO_4$			
Ortho-Nitroaniline				
Oxalic Acid		4		
Oxydipropionitrile		4		
Oxygen (nontoxic)				
Oxygen Difluoride →	$HF + O_2$			
Paraformaldehyde				
Paraldehyde				
Pentaborane →	$H_3BO_3 + H_2$			
Pentane		3		
Peracetic Acid		4		

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Perchloric Acid		4		
Perchloroethylene		1		
Perchloro-Methyl-Mercaptan			3	
Perchloryl Fluoride	3		3	
Petroleum Ether		3		
Phenanthrene		3		
Phenol		3	3	1
Phenylcarbylamine Chloride			1	
Phenylethanolamine				
Phenyltrichlorosilane	→ Cl_2 + Chlorophenol + SiO_2			
Phosphine	1	3		
Phosphoric Acid		4	4	
Phosphoric Anhydride		4		
Phosphorous		2		
Phosphorous Oxybromide	→ $HBr + H_3PO_4$			
Phosphorous Oxychloride	→ $H_3PO_4 + HCl$			
Phosphorous Pentachloride	→ $HCl + H_3PO_4$			
Phosphorous Pentasulfide	→ $H_2S + H_3PO_4$			
Phosphorous Sesquisulfide				
Phosphorous Tribromide	→ $HBr + H_3PO_4$			
Phosphorous Trichloride	→ $HCl + H_3PO_4$			
Phthalic Anhydride		4		
Picric Acid		4	2	
Polybutene				
Polypropylene Glycol Methyl Ether	1			
Potassium (metal)	→ $KOH + H_2$			
Potassium Acetate			3	
Potassium Arsenate		4		
Potassium Arsenite		4		
Potassium Bifluoride		4		
Potassium Bromate				
Potassium Chlorate		3		
Potassium Chloride		3	3	
Potassium Chromate	4	4	4	4
Potassium Cupric Cyanide	2	4		
Potassium Cyanide	2	4		
Potassium Dichloroisodyanurate	2	4		
Potassium Dichromate		4		4
Potassium Ferricyanide	2	4		
Potassium Ferrocyanide	2	4		
Potassium Fluoride		4		
Potassium Hydroxide		4	4	
Potassium Iodide		4	2	

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Potassium Nitrate		3		
Potassium Nitrite	3			
Potassium Perchlorate		2		
Potassium Permanganate		4		
Potassium Peroxide		4		
Potassium Persulfate				
Potassium Phosphate		4		
Potassium Silicofluoride		4		
Potassium Sulfate				
Potassium Sulfite			4	
Potassium Thiocyanate	2	4		
Propane-not persistent				
Propiolactone		3		
Propioaldehyde		3		
Propionic Acid		4		
Propionic Anhydride → Propenol + Propionic Acid				
n-Propyl Acetate		1		
n-Propyl Alcohol	1	3		
Propylamine		3	3	
Propylene		3	1	
Propylene Butylene Polmer				
Propylene Glycol		3		
Propylene Imine				
Propylene Oxide		3		
Propylene Tetramer				
Propyl Mercaptan			3	
Propyl Nitrate				
Propy Trichlorosilane → Cl_2 + Chloropropane + SiO_2				
Pyridal Mercuric Acetate	1	3		
Pyridine		3	1	
Pyrocatechol		3	3	
Pyrogallol		3		
Pyro Sulfuryl Chloride → HCl + SO_2 + SO_3				
Pyroxylin				
Quinoline		3	1	
Quinone		3		
Resins		4		
Resorcinol		3	3	
Salicylic Acid		4	2	
Saponins		1	3	
Selenium	2	4		2
Silicon Chloride (tetra) → HCl + SiO_2				
Silicon Tetrafluoride → HF + SiO_2				
Siver Cyanide	2			
Siver Nitrate	2	2		

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Sodium (metal)	→ NaOH + H_2			
Sodium Acetate		3	3	
Sodium Aluminate		4		
Sodium Aluminate Hydride	→ H_2 + NaOH			
Sodium Amide	→ NH_3 - NaOH			
Sodium Arsenate	2	4		
Sodium Arsenite	2	2		
Sodium Azide		3		
Sodium Bicarbonate		4	4	4
Sodium Bifluoride		4		
Sodium Bisulfate		3		
Sodium Bisulfite		4		
Sodium Borate	4	4		
Sodium Bromate				
Sodium Butyl Mercaptide		3	3	
Sodium Carbonate		4	4	4
Sodium Chlorate	3	3		3
Sodium Chlorite			3	
Sodium Chromate	4	4		
Sodium Cyanide	2	4		
Sodium Dichloroisodyanurate	2	4		
Sodium Dichromate	4	4		
Sodium Ferrocyanide	2	4		
Sodium Fluoride	4	4		4
Sodium Formate		4		
Sodium Hydride	→ NaOH + H_2			
Sodium Hydrosulfide		4		
Sodium Hydrosulfite		2		
Sodium Hydroxide		4	4	
Sodium Iodide		4	2	
Sodium Methylate				
Sodium Nitrate		3	3	
Sodium Nitrite		3		
Sodium Oxalate		4		
Sodium Perborate		4		
Sodium Perchlorate		1		
Sodium Permanganate		4		
Sodium Peroxide		4		
Sodium Phosphates	3	3	3	
Sodium Picramate		4	2	
Sodium Potassium Alloy	→ NaOH + KOH + H_2			
Sodium Silicate		4		
Sodium Sulfate		3	3	3
Sodium Sulfide		4	4	
Sodium Sulfite		3		
Sodium Thiocyanate	2			

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Sodium Triphosphate		3		
Strontium Arsenite		4		
Strontium Chlorate		4		
Strontium Nitrate		4		
Strontium Peroxide		4		
Strychnine	3		3	
Styrene (monomer)		1	1	
Sorbitol				
Succinic Acid		4		
Sulfolane		1		
Sulfur	3	3	1 (taste) 3 (colloidal)	
Sulfur Chloride	→ HCL + H_2SO_4			
Sulfur Dioxide		1		
Sulfur Hexafluoride	4			
Sulfuric Acid		4		
Sulfur Trioxide	→ H_2SO_4			
Sulfuryl Chloride	→ $H_2SO_4 + Cl_2$			
Sulfuryl Fluoride	→ $HF + H_2SO_4$			
Tannic Acid			4	4
Tartaric Acid			4	
Tertiary Butyl Isopropyl Benzene				
Tetradecanol (sol < cc)				
1-Tetradecene				
Tetraethylene Glycol		3		
Tetraethyl Lead (and mix)	3	3		4
Tetrafluoroethylene				
Tetrahydronapthalene		1		
Tetramethyl Lead	3			4
Tetrapropylene		3		
Thallium Sulfate	2			4
Thionyl Chloride	→ $SO_2 + HCl$			
Thiophene		3		
Thiophenol			1	
Thiophosphoryl Chloride	→ $H_3PO_4 + SO_2$			
Thorium (metal)				
Thorium Nitrate		4		
Tin Tetrachloride		4		
Titanium Sulfate				
Titanium Tetrachloride		4		
Toluene	3	3		4
Toluene Diisocyanate	2			
Toluidine		3	3	
Triamylamine			3	
Tributylamine		3	3	

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Trichlorobenzene		3		
Trichloroethane		3		
Trichloroethylene		3		
Trichlorofluoromethane		1		
Trichlorofluorosilane	→ Cl_2 + HCl			
Trichloroisocyanuric Acid	2		2	
Trichlorophenol			1	
Trichlorosilane	→ Cl_2 + HCl			
Tridecanol				
Triethanolamine		1		
Triethylamine		3		
Triethyl Benzene		3		
Triethylene Glycol		3		
Triethylene Tetramine			1	
Trimethylamine		3	1	
Trimethylchlorosilane	→ Chloromethane + Ethane			
Trinitrobenzene		2		
Trinitrobenzoic Acid		4		
Trinitroresorcinol				
Tripropylene		3		
Turpentine		3		
Undecanol				
1-Undecene				
Uranyl Nitrate	4			
Urea (plus salts)		3		
Unsymetrical Dimethyl Hydrazine		3		
Valeraldehyde		3		
Vanadium Oxytrichloride	→ V_2O_5 + HCl			4
Vanadium Tetrachloride	→ V_2O_5 + HCl			4
Vinyl Acetate		3	3	
Vinyl Chloride - nonpersistent				
Vinyl Ether				
Vinyl Fluoride				
Vinylidene Chloride		3		
Vinyl Methyl Ether	1			
Vinyl Toluene		3		
Vinyl Trichlorosilane	→ Cl_2 + Vinyl Chloride + SiO_2			
Waxes				
Xylenes		3	1	3
Xylenols		3	1	
Xylyl Bromide				
Zinc Acetate			4	
Zinc Ammonium Nitrate			4	
Zinc Arsenate			4	
Zinc Arsenite			4	
Zinc Chlorate			4	
Zinc Chloride		4	4	
Zinc Cyanide	2		4	

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Zinc Ethyl	→ Ethane + $Zn(OH)_2$			
Zinc Nitrate		4	4	
Zinc Oxide			4	
Zinc Permanganate	4	4	4	
Zinc Peroxide	4	4	4	
Zinc Sulfate		4	4	4
Zirconium (metal)				
Zirconium Picramate			4	
Fungicides				
Captan		3		
Copper Naphthenate				
Dichloronaphthoquinone		1		
Ferbam		1		
Mercury Fungicides	1			
Nabam		1		
Pentachlorophenol		3		
Thiram		3		
ZDD		1		
Herbicides				
Ammonium Sulfamate		3		3
2,4-D Acid		3	1	1
2,4-D, Esters, Salt		E = 1 S=3	1	3
CMU	3	3		3
Dalapon		3		1
Diuron		1		
DNBP				
DNBP (ammonium salt)			3	
Endothal		3		3
IPC		3		
MCP		3		
Phenyl Mercuric Acetate				
Sesone				
Silvex (2,4,5-T)		3		
TBA		3		
TCA		3		
2,4,5-T (acid, esters, salts)		3		
Insecticides, Fumigants and Rodenticides				
Aldrin-Toxaphene Group		1		

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
Benzene Hexachloride (Lindane)		1	1	
Chlordane		1		
Chlorthion		1		
DDD (TDE or Rhothane)		3		
DDT		3	3	
Diazinon		1		
Dicapthon		3		
Dieldrin	1	1		
Dipterex		3		
Dibromochloropropane				
Endrin		1		
Guthion		1		
Hepthachlor		1		
Isodrin		1		
Kelthane		1		
Malathion		1		
Metasystex		3		
Methoxchlor		1		
Methyl Parathion		1		
Nicotine	1	1		
Ovotran		3		
Phosdrin		1		
Pyrethrum		1		
Retenone		1		
Schradan		1		3
Sevin		3		
Simazine		3		
Sulfoxide		1	1	
Systox		3		
TEPP (HETP)	3	3		
Tiodan		1		
Toxaphene		1	1	
Others				
Fenuron		1		
Kuron		1		
Omazene		3		
Perthane		1		
Tedion		3		
Vapam		1		

TABLE C-3. (continued)

Hazardous Materials	Human Toxicity	Fish Toxicity	Aesthetic	Plant Toxicity
4 Amino - m-toluene - sulfonic acid		4		
Anthacene				
Dichloropropene		3		
Diethyl Amine		3		
Ferrous Sulfide		4		
Monochloroacetone				
Naphthylamine		3		
Nitrogen		1		
Sodium Chloride		3	3	3
Tetrahydrofuran				

TABLE C-4. Water Use Classification System by Beneficial Use

Human Toxicity

Nondetectable Countermeasure Unavailable

- Carbon Disulfide
- Carbon Tetrachloride
- Chloroform
- Dichloroethyl Ether
- Dimethyl Ether
- Dioxane
- Ethers
- 2-Ethyl Hexanol-1
- Isoprene
- Mercuric Ammonium Chloride
- Mercuric Benzoate
- Mercuric Bromide
- Mercuric Chloride
- Mercuric Cyanide
- Mercuric Iodide
- Mercuric Nitrate
- Mercuric Oleate
- Mercuric Oxide
- Mercuric Oxycyanide
- Mercuric Potassium Cyanide
- Mercuric Salicylate
- Mercuric Sulfo Cyanate
- Mercurous Bromide
- Mercurous Chloride
- Mercurous Gluconate
- Mercurous Iodide
- Mercurous Nitrate
- Mercurous Sulfate
- Mercury
- Mercury Acetate
- Methyl Alcohol
- Phosphine
- Propylene Glycol Methyl Ether
- n-Propyl Alcohol
- Pyridial Mercuric Acetate
- Vinyl Methyl Ether
- Mercury Fungicides
- Nicotine

Insecticides

- Dieldrin

Nondetectable Countermeasure Available

- Acetone Cyanohydrin
- Acetonitrile
- Acrylonitrile
- Ammonium Ferrocyanide
- Arsenic Compounds
- Barium Cyanide
- Calcium Arsenate
- Chloroisocyanuric Acid
- Fatty Acids
- Hydrogen Cyanide
- Lactonitrile
- Lead Cyanide
- Lead Sulfocyanate
- Nickel Ammonium Sulfate
- Nickel Chloride
- Nickel Sulfate
- Oleic Acid
- Potassium Cupric Cyanide
- Potassium Cyanide
- Potassium Dichloroisocyanunite
- Potassium Ferricyanide
- Potassium Ferrocyanide
- Potassium Thiocyanate
- Selenium
- Silver Cyanide
- Silver Nitrate
- Sodium Aresenate
- Sodium Arsenite
- Sodium Cyanide
- Sodium Dichloroisocyanuric
- Sodium Ferrocyanate
- Sodium Thiocyanate
- Thallium Sulfate
- Toluene Diisocyanate
- Trichloroisocyanuric Acid
- Zinc Cyanide

Detectable Countermeasure Unavailable

- Acetaldehyde
- Ammonia
- Aniline
- Bromoacetone
- Chloromethane
- Copper Acetoarsenite
- Ethyl Alcohol
- Ethylene Diamine
- Methyl Chloride
- Motor Fuel Anti-knock Compound
- Perchloryl Fluoride
- Sodium Chlorate
- Sodium Phosphates
- Strychnine
- Sulfur
- Toluene
- CMU (Herbicide)
- TEPP (Insecticide)
- Potassium Nitrite
- Tetrethyl Lead
- Tetramethyl Lead

Detectable Countermeasure Available

- Barium Acetate
- Barium Carbonate
- Cadmium Chloride
- Cadmium Nitrate
- Cadmium Sulfate
- Calcium Carbonate
- Calcium Chloride
- Calcium Fluoride
- Calcium Hydroxide
- Calcium Nitrate
- Calcium Phosphate
- Calcium Sulfate
- Chromic Acid
- Chromium Sulfate
- Copper Chloride
- Copper Nitrate
- Hydrofluoric Acid
- Hydrogen Bromide
- Lead Acetate
- Lead Arsenate
- Lead Arsenite
- Lead Chloride
- Lead Nitrate
- Lead Sulfate
- Lithium Carbonate
- Lithium Chloride
- Lithium Ferrosilicon
- Lithium Fluoride
- Lithium Hydroxide
- Lithium Hypochlorite
- Lithium Peroxide
- Lithium Silicon
- Lithium Sulfate
- Magnesium Chloride
- Monofluorphosphoric Acid
- Nickel Nitrate
- Nitric Acid
- Potassium Chromate
- Sodium Borate
- Sodium Chromate
- Sodium Dichromate
- Sodium Fluoride
- Sulfur Hexa Fluoride
- Uranyl Nitrate
- Zinc Permanganate
- Zinc Peroxide

TABLE C-4. (continued)

Fish Toxicity

Nondetectable Countermeasure Unavailable

Acetylene
Acridene
Benzene Phosphorous Dichloride
Benzyl Bromide
Benzyl Chloride
Butadiene
Carbon Monoxide
Chloramine T
Chlorine
Chlorobenzene
Chloroform
Crotonaldehyde
Cumene
Cyclohexane
Diethylamine
Diethyl Benzene
Diisobutyl Ketone
Diisopropylamine
Dimethylamine
Dimethyldioxane
Dinitrotoluene
Dipentene
Epichlorohydrin
Ethyl Benzene
Ethylene Cyanohydrin
Ethylene Dichloride
Ethyl Phthalate
Furfuryl Alcohol
Heptane
Isooctanol
Isophorone
Mercury
Mesityl Oxide
2-Methyl-5 Ethyl Pyridine
Morpholine
Naphthol
Nicotine Salicylate Tartrate & Sulfate
Nitrogen
Perchloroethylene
Propyl Acetate
Saponins
Sodium Perchlorate
Styrene
Sulfolane
Sulfur Dioxide
Tetrahydronapthalene
Trichloro Fluoromethane
Triethanolamine

Fungicides
Dichloro Napthoquinone
Ferbam
Nabam
ZOO

Herbicides
214-D Ester
Diuran

Nondetectable Countermeasure Available

Ammonium Ferrocyanide
Arsenic Compounds
Calcium Arsenate
Fatty Acids
Hydrogen Cyanide
Lithium Hypochlorite
Nickel Ammonium Sulfate
Nickel Carbonyl
Nickel Nitrate
Phosphorous
Potassium Perchlorate
Silver Nitrate
Sodium Aresenite
Sodium Hydrosulfite

Detectable Countermeasure Unavailable

Acetaldehyde
Acetaldol
Acetamide
Acetone
Acetyl Benzoyl Peroxide
Acetyl Peroxide
Acrolein
Alkyl Aryl Sulfonate
Allyl Alcohol
Allyl Chloride
N-Amino Ethyl Ethanolamine
Ammonia
Ammonium Acetate
Ammonium Chloride
Ammonium Nitrate
Ammonium Sulfate
Ammonium Sulfite
Amyl Acetate
Amyl Alcohol
Amyl Amine
Amyl Bromide
Aniline
Antimony Trioxide
Benzaldehyde
Benzene
Benzoyl Peroxide
Benzyl Alcohol
Benzylamine
Berylium Dust
Bromine
Butane
Butyl Acetate
Butyl Acrylate
Butyl Amine
Butyl Alcohol
Butyl Hydroperoxide
n-Butyraldehyde
Carbon Tetrachloride
Chenopodium Oil
Chlorohydrin
Chlorophenol
Chloroprene
Citric Acid
Cresol
Cumene Hydroperoxide
Cupric Chrome Gluconate
Cupric Oxide
Cyanogen Chloride
Cyclohexane Carboxylic Acid
Cyclohexanol
Cyclohexanone
Decyl Alcohol
Detergents
Diamyl Amine
Dibutyl Peroxide
Dibutyl Phthalate
Dibutyl Thiourea

Detectable Countermeasure Available

Abietic Acid
Acetic Acid
Acetic Anhydride
Acetone Cyanohydrin
Acetonitrile
Acrylic Acid
Acrylonitrile
Adipic Acid
Adiponitrile
Aluminum Ammonium Sulfate
Aluminum Chloride
Aluminum Nitrate
Aluminum Sulfate
4-Amino-m-toluene Sulfonic Acid
Ammonium Arsenate
Ammonium Carbonate
Ammonium Chromate
Ammonium Dichromate
Ammonium Fluoride
Ammonium Hydroxide
Ammonium Molybdate
Ammonium Permanganate
Ammonium Persulfate
Ammonium Sulfide
Ammonium Thiocyanate
Antimony Potassium Tartrate
Antimony Trichloride
Antimony Trifluoride
Barium Acetate
Barium Carbonate
Barium Chloride
Barium Fluoride
Barium Nitrate
Barium Permanganate
Barium Peroxide
Benzanine Sulfonic Acid
Benzoic Acid
Benzonitrile
Boric Acid
Boron Trifluoride
Butyric Acid
Cadmium Chloride
Cadmium Nitrate
Cadmium Sulfate
Calcium Carbonate
Calcium Chloride
Calcium Fluoride
Calcium Fluosilicate
Calcium Hydroxide
Calcium Nitrate
Calcium Phosphate
Calcium Sulfate
Caustic Potash
Caustic Soda
Chromic Acid
Chromium Sulfate
Cobalt Chloride
Cobalt Nitrate
Copper Chloride

TABLE C-4. (continued)

Fish Toxicity (continued)

Nondetectable Countermeasure Unavailable	Nondetectable Countermeasure Available	Detectable Countermeasure Unavailable	Detectable Countermeasure Available
Insecticides		Dichlorobutane	Copper Nitrate
Aldrin-toxaphene Group		Dichloroethylene	Copper Sulfate
Benzene Hexachloride		Dichloroethyl Ether	Dichlorobenzene
Chlordane		1;2-Dichloro Propane	Ferric Chloride
Chlorthion		Dichloropropene	Ferric Oxide
Diazinon		Dicyclopentadiene	Ferric Potassium Sulfate
Dieldrin		Diethanolamine	Ferric Sulfate
Endrin		Diethyl Amine	Ferrous Chloride
Guthion		Diethylene Glycol	Ferrous Oxide
Heptachlor		Diethylene Glycol Mono-ether	Ferrous Sulfide
Isodrin		Diethylentriamine	Ferrous Sulfite
Kelthane		Diisobutylene	Formic Acid
Malathion		Dimethyl Hydrazine	Fumaric Acid
Methoxychlor		Dinitorbenzene	Gallic Acid
Nicotine		Dinitrocresols	Hydrochloric Acid
Methyl Parathion		Dinitrophenol	Hydrofluoric Acid
Phosdrin		Dipropylene Glycol	Hydrogen Chloride (Anhyd)
Pyrethrum		Dyes	Hydrogen Peroxide
Rotenone		Dodecyl Benzene	Iodacetic Acid
Schraden		Ethanolamine	Lactic Acid
Sulfoxide		Ethoxytriglycol	Lactonitrile
Thiodan		Ethyl Acetate	Lead Acetate
Toxaphene		Ethyl Acrylate	Lead Arsenate
		Ethyl Alcohol	Lead Arsenite
Others		Ethylamine	Lead Chloride
Fenuron		Ethyl Chloride	Lead Nitrate
Kuron		Ethylene	Lead Sulfate
Perthane		Ethylenediamine	Lithium Carbonate
Vapam		EDTA	Lithium Chloride
		Ethylene Glycol	Lithium Fluoride
		Ethylene Glycol Mono Ether	Lithium Peroxide
		Ethylene Glycol Mono Ether Acetate	Magnesium Chloride
		Ethylene Oxide	Magnesium Fluoride
		Ethyleneimine	Magnesium Nitrate
		2-Ethyl Hexyl Acrylate	Magnesium Silicofluoride
		-2-Ethyl 3-Propyl Acrolein	Magnesium Sulfate
		Formaldehyde	Maleic Anhydride
		Furfural	Manganese Chloride
		Glycerin	Manganese Nitrate
		Glycol Diacetate	Manganese Sulfate
		Glyoxal	Methyl Butyraldehyde
		Guaiacol	Naphthalic Acid
		Heptanol	Nickel Chloride
		Heptene	Nickel Sulfate
		Hexane	Nitric Acid
		Hexanol	Oxalic Acid
		Hexylene Glycol	Oxydipropionitrile
		Hydrazine	Peracetic Acid
		Hydrogen Sulfide	Perchloric Acid
		Hydroguinone	Phosphoric Acid
		Hydroxylamine	Phosphoric Anhydride
		Hypochlorite	Phthalic Anhydride
		Hypoiodate	Picric Acid
		Iodine	Potassium Arsenite
		Isobutyl Acetate	Potassium Bifluoride
		Isobutyraldehyde	Potassium Cupric Cyanide
			Potassium Cyanide
			Potassium Dichloroisocyanurate
			Potassium Dichromate
			Potassium Ferricyanide

TABLE C-4. (continued)

Fish Toxicity (continued)

Nondetectable Countermeasure Unavailable	Nondetectable Countermeasure Available	Detectable Countermeasure Unavailable	Detectable Countermeasure Available
		Isodecaldehyde	Potassium Ferrocyanide
		Isodecanol	Potassium Fluoride
		Isooctyl Aldehyde	Potassium Hydroxide
		Isoprene	Potassium Iodide
		Isopropyl Alcohol	Potassium Permanganate
		Isopropyl Acetate	Potassium Peroxide
		Isopropylamine	Potassium Phosphate
		Isopropyl Ether	Potassium Silicofluoride
		Lauroyl Peroxide	Potassium Thiocyanate
		Mercaptons	Propionic Acid
		Mercuric Benzoate	Resins
		Mercuric Chloride	Salicylic Acid
		Mercuric Cyanide	Selenium
		Mercuric Nitrate	Sodium Aluminate
		Mercuric Oleate	Sodium Arsenate
		Mercuric Oxycyanide	Sodium Bicarbonate
		Mercuric Salicylate	Sodium Bifluoride
		Methyl Acrylate	Sodium Bisulfite
		Methyl Alcohol	Sodium Borate
		Methyl Amines	Sodium Carbonate
		Methyl Amyl Acetate	Sodium Chromate
		Methyl Amyl Alcohol	Sodium Cyanide
		Methyl Bromide	Sodium Dichloroisocyanurate
		Methyl Chloride	Sodium Dichromate
		Methylene Chloride	Sodium Ferrocyanide
		Methyl Formal and Formate	Sodium Fluoride
		Methyl Hydrazine	Sodium Formate
		Methyl Isobutyl Ketone	Sodium Hydrosulfide
		Methyl Mercapton	Sodium Hydroxide
		Methyl Methacrylate	Sodium Iodide
		Methyl Naphthoquinone	Sodium Oxalate
		Mineral Spirits #10	Sodium Perborate
		Monoethanol Amine	Sodium Permanganate
		Monoethylamine	Sodium Peroxide
		Mono Isopropanolamine	Sodium Picramate
		Monmethyl Hydrazine	Sodium Silicate
		Naphthalene	Sodium Sulfide
		Naphthoquinone	Sodium Thiosulfate
		Nitroaniline	Strontium Arsenite
		Nitrobenzene	Strontium Chlorate
		Nitrophenol	Strontium Nitrate
		Nitropropane	Strontium Peroxide
		Nitrotoluene	Succinic Acid
		Nonane	Sulfuric Acid
		Nonene	Thorium Nitrate
		Nonylphenol	Tin Tetrachloride
		Octyl Alcohols	Titanium Tetrachloride
		Pentane	Trinitro Benzoic Acid
		Petroleum Ether	Zinc Chloride
		Phenanthrene	Zinc Nitrate
		Phenol	Zinc Permanganate
		Phosphine	Zinc Peroxide
		Potassium Chlorate	Zinc Sulfate
		Potassium Chloride	Acetronitrile
		Potassium Nitrate	
		Propiolactone	
		Propiolaldehyde	
		Propyl Alcohol	

TABLE C-4. (continued)

Fish Toxicity (continued)

Nondetectable Countermeasure Unavailable	Nondetectable Countermeasure Available	Detectable Countermeasure Unavailable	Detectable Countermeasure Available
		Propylamine	
		Propylene	
		Propylene Glycol	
		Propylene Oxide	
		Pyridal Mercuric Acetate	
		Pyridine	
		Pyrocatechol	
		Pyrogallol	
		Quinoline	
		Quinone	
		Resorcinol	
		Sodium Acetate	
		Sodium Azide	
		Sodium Bisulfate	
		Sodium Butyl Mercaptide	
		Sodium Chlorate	
		Sodium Chloride	
		Sodium Nitrate	
		Sodium Nitrite	
		Sodium Phosphates	
		Sodium Sulfate	
		Sodium Sulfite	
		Sodium Triphosphate	
		Sulfur	
		Tetraethylene Glycol	
		Tetraethyl Lead	
		Tetrapropylene	
		Thiophehe	
		Toluene	
		Toluidine	
		Tributylamine	
		Trichlorobenzene	
		Trichloreothane	
		Trichloroethylene	
		Triethylamine	
		Triethyl Benzene	
		Triethylene Glycol	
		Trimethylamine	
		Trinitro Benzene	
		Tripropylene	
		Turpentine	
		Urea	
		Unsym. Dimethyl Hydrazine	
		Valeraldehyde	
		Vinyl Acetate	
		Vinylidene Chloride	
		Vinyl Toluene	
		Xylenes	
		Xylenols	
		Fungicides	
		Captan	
		Pentachlorophenol	
		Thiram	

TABLE C-4. (continued)

Fish Toxicity (continued)

Nondetectable Countermeasure Unavailable	Nondetectable Countermeasure Available	Detectable Countermeasure Unavailable	Detectable Countermeasure Available
		Herbicides	
		Ammonium Sulfamate	
		2,4-D Acid	
		2,4-D Salt	
		CMU	
		Dalapon	
		Endothal	
		IPC	
		MCP	
		Silvex	
		TBA	
		TCA	
		2,4,5-T Acid, Esters, Salts	
		Insecticides	
		DDD (TDE or Rothane)	
		DDT Dicapthon	
		Dipterex	
		Metasystox	
		Ovatron	
		Sevin	
		Simazine	
		Systox	
		TEPP (HETP)	
		Others	
		Omazene	
		Tedion	

TABLE C-4. (continued)

Aesthetic

Nondetectable Countermeasure Unavailable	Nondetectable Countermeasure Available	Detectable Countermeasure Unavailable	Detectable Countermeasure Available
Acetone	Acrylonitrile	Allyl Chloride	Acetic Acid
Acetophenone	Benzoic Acid	Aminoethyl Ethanolamine	Calcium Carbonate
Alkyl Aryl Sulphonate	Cresotic Acid	Ammonia	Calcium Chloride
Allylamine	Hydrogen Cyanide	Ammonium Acetate	Calcium Sulfate
Ammonium Sulfide	Picric Acid	Ammonium Arsenate	Copper Chloride
Amyl Mercaptan	Potassium Iodide	Ammonium Carbonate	Copper Nitrate
Benzaldehyde	Salicylic Acid	Ammonium Chloride	Ferric Sulfate
Butyl Amine	Sodium Iodide	Ammonium Chromate	Ferrous Chloride
Butyl Alcohol	Sodium Picramate	Ammonium Dichromate	Ferrous Sulfate
Butyl Mercaptan	Trichloroisocyanuric Acid	Ammonium Ferrocyanide	Hydrochloric Acid
Camphor		Ammonium Fluoride	Hydrogen Chloride (Anhyd.)
Carbon Disulfide		Ammonium Hydroxide	Hydrogen Peroxide
Carbon Tetrachloride		Ammonium Molybdate	Magnesium Chloride
Cresol		Ammonium Nitrate	Magnesium Nitrate
Cyclohexylamine		Ammonium Perchlorate	Magnesium Sulfate
Dichloroisopropyl Ether		Ammonium Permanganate	Phosphoric Acid
Diethylenetriamine		Ammonium Persulfate	Potassium Chromate
Dimethylamine		Ammonium Picrate	Potassium Hydroxide
Dimethyldioxane		Ammonium Sulfate	Potassium Sulfide
Dinitrobenzoyl		Ammonium Sulfite	Sodium Bicarbonate
Dinitrophenol		Ammonium Thiocyanate	Sodium Carbonate
Dodecyl Mercaptan		Amyl Acetate	Sodium Hydroxide
Ethylamine		Aniline	Sodium Sulfide
Ethylenediamine		Benzene	Tannic Acid
Guaiacol		Chenopodium Oil	Tartaric Acid
Hexamethylene Diamine		Chlorine	Zinc Acetate
Isoprene		Chlorophenol	Zinc Ammonium Nitrate
Isopropylamine		Dichloro Phenol	Zinc Arsenate
Mesitylene		Dyes	Zinc Arsenite
Methylamines		Formaldehyde	Zinc Chlorate
2-Methyl, 5-Ethyl Pyridine		Furfural	Zinc Chloride
Monoisopropanolamine		Hydrogen Sulfide	Zinc Cyanide
Naphthol		Hydroxylamine	Zinc Nitrate
B-Naphthylamine		Isopropyl Mercaptan	Zinc Parmanganate
Nitrobenzene		Mercaptans	Zinc Peroxide
Nitrophenol		Mercaptoethanol	Zinc Sulfate
Nonyl Phenol		Methyl Mercaptan	Zirconium Picramate
Octyl Alcohols		Methyl Methacrylate	
Penylcarbylamine Chloride		Methyl Salicylate	
Propylamine		Perchloro-Methyl-Mercaptan	
Propylene Imine		Phenol	
Pyridine		Potassium Acetate	
Quinoline		Potassium Chloride	
Styrene		Propylamine	
Sulfur (taste)		Propyl Mercaptan	
Thiophenol		Pyrocatechol	
Trichlorophenol		Resorcinol	
Triethylene Tetramine		Saponins	
Trimethylamine		Sodium Acetate	
Xylenes		Sodium Butyl Mercaptide	
Xylenols		Sodium Chloride	
		Sodium Chlorite	

TABLE C-4. (continued)

Aesthetic (continued)

Nondetectable Countermeasure Unavailable	Nondetectable Countermeasure Available	Detectable Countermeasure Unavailable	Detectable Countermeasure Available
Herbicides		Sodium Nitrate	
2,4-D Acid		Sodium Phosphates	
2,4-D Esters		Sodium Sulfate	
2,4-D Salts		Strychnine	
		Sulfur (colloidal)	
Insecticides		Toluidene	
Benzene Hexachloride (Lindane)		Triamylamine	
		Tributylamine	
Sulfoxide		Vinyl Acetate	
Toxaphene			
		Herbicides	
		DNBP (Ammonium Salt)	
		Insecticides	
		DDT	

TABLE C-4. (continued)

Plant Toxicity

Nondetectable Countermeasure Unavailable	Nondetectable Countermeasure Available	Detectable Countermeasure Unavailable	Detectable Countermeasure Available
Dimethylamine	Aresenic Compounds	Acrolein	Aluminum Ammonium Sulfate
Phenol	Calcium Arsenate	Beryllium Dust	Aluminum Chloride
	Nickel Ammonium Sulfate	Chlorine	Aluminum Fluoride
Herbicides	Nickel Carbonyl	Sodium Chloride	Aluminum Nitrate
2,4-D Acid	Nickel Chloride	Sodium Sulfate	Aluminum Oxide
Dalapon	Nickel Nitrate	Xylenes	Aluminum Sulfate
	Nickle Sulfate		Butyric Acid
	Selenium	Herbicides	Cadmium Chloride
		Ammonium Sulfamate	Cadmium Nitrate
		2,4-D Esters	Cadmium Sulfate
		2,4-D Salts	Calcium Chloride
		CMU	Caustic Potash
		Endothol	Caustic Soda
			Chromic Acid
		Insecticides	Chromium Sulfate
		Schraden	Cobalt Chloride
			Cobalt Nitrate
			Cobalt Sulfate
			Hydrogen Cyanide
			Lead Acetate
			Lead Arsenate
			Lead Arsenite
			Lead Chloride
			Lead Cyanide
			Lead Nitrate
			Lead Sulfate
			Lead Sulfocyanate
			Magnesium Chloride
			Magnesium Sulfate
			Nickel Cyanide
			Potassium Chromate
			Potassium Dichromate
			Sodium Bicarbonate
			Sodium Carbonate
			Sodium Fluoride
			Tannic Acid
			Tetraethyl Lead
			Tetramethyl Lead
			Thallium Sulfate
			Titanium Tetrachloride
			Vanadium Oxytrichloride
			Vanadium Tetrachloride
			Zinc Sulfate

APPENDIX D

TRANSPORTATION CONSIDERATIONS AND HISTORICAL DATA

Appendix D contains supplementary material to transportation, stationary source, and historical data considerations.

Tables D-1 and D-2 list the total tonnage of individual hazardous commodities handled in the United States in 1968. This is followed by a listing of the individual ports and waterways with a tonnage figure representative of all the hazardous commodities handled in 1968 as defined in Table D-1. It should be noted that oil and petroleum products were excluded. Hence, these figures do not compare with the total waterborne tonnage figures listed by Booz-Allen & Hamilton in Table 1.

Tables D-3 and D-4 present production and price index trends for chemical classes.

Figures D-1 through D-10 illustrate the geographical locations of production sites and market areas for selected high priority materials. These maps should help demonstrate those areas most likely exposed to spillage of particular materials. Considerations such as these are not amenable to numerical formulation.

Figures D-11 and D-12 record the locations of fish kills caused by agricultural chemicals, namely fertilizer and pesticides. While both maps highlight agricultural areas, the pesticide chart indicates that pesticide usage is indeed widespread. Chemical plant and transportation spill sites are detailed in Figures D-13 and D-14. These for the most part are concentrated in the industrial East, Texas, and the Great Lakes regions. However, incident sites appear in nearly every state and are not always centered around large cities or production sites. The implications are obvious. This nation's massive network of transportation systems has brought the threat of hazardous material to all parts of the country.

Tables D-5 through D-13 are summaries of fish kills for the years 1960-1968. Raw data were taken from the FWQA fish kill reports.

These tables are followed by a brief analysis of spills that were reported for the state of California and Illinois.

TABLE D-1. National Summary of Waterborne Hazardous Materials Quantities - 1968[(100)]

National Totals (tons of 2000 lbs.)

Total	Imports	Exports	Domestic
67,973,725	5,311,291	16,921,113	45,791,321

Individual Commodities (tons of 2000 lbs.)

Salt	3,790,882
Sulphur, dry	2,701,824
Sulphur, liquid	8,484,747
Sodium hydroxide	3,258,554
Dyes	178,234
Alcohols	2,807,540
Benzen, Toulene	3,222,661
Sulfuric Acid	3,384,272
Basic chemicals	19,471,103
Plastic materials	1,354,479
Drugs	82,257
Soap, toiletries	284,402
Paints	123,692
Gum, wood chemicals	892,261
Nitrogenous fertilizers	1,047,105
Potassic fertilizers	312,050
Superphosphate	686,633
Pesticides	269,893
Fertilizers	8,272,166
Misc. chemical products	4,056,561
Napthal solvents	3,792,409

TABLE D-2. Hazardous Materials Quantities Handled in U.S. Ports - 1968(100)

Port	Total Tons
Alabama	
Mobile Harbor	360,356
Black Warrior and Tombigbee Rivers	654,059
Waterway connecting the Tombigbee and Tennessee Rivers, Ala. & Miss.	10,186
Alaska	
Ketchikan Harbor	67,412
Wrangell Harbor	217
Sitka Harbor	82,330
Skagway Harbor	93
Anchorage	14,263
Cordova Harbor	47
Juneau Harbor	589
Kodiak Harbor	161
Metlakatla Harbor	15
Home Harbor	1
Petersburg Harbor	397
Seward Harbor	831
Valdez Harbor	12,806
Other Southeastern Ports (NET)	2,806
Southerly Side of Alaska Peninsula (NET)	26,047
Whittier Harbor	6,051
Arkansas	
Ouachita and Black Rivers, Arkansas & Louisiana	187,471
California	
San Diego Harbor	355,360
Long Beach Harbor	847,085
Los Angeles Harbor	1,100,409
Suisun Bay Channel	111,413
Sacramento River (including Commerce of Sacramento River Deepwater Ship Channel & the Port of Sacramento	1,965
California (cont'd.)	
San Joaquin River	109,466
San Francisco Harbor	107,598
Oakland Harbor	206,207
Richmond Harbor	653,518
San Pablo Bay & Mare Island Strait	476,404
Carquinez Strait	472,670
Humboldt Harbor and Bay	117,200
Nonproject-Other San Francisco Bay Area Ports	2,468
Connecti[illegible]	
New London Harbor	44,044
Thames River	64,188
Conn. River below Hartford	4,841
New Haven Harbor	321,869
Housatonic River	--
Bridgeport Harbor	9,354
Norwalk Harbor	--
Stamford Harbor	--
Delaware	
Wilmington Harbor	147,310
Inland Waterway - Delaware River to Chesapeake	762,067
Broad Creek River	1,958
Florida	
Jacksonville Harbor	495,920
St. John's River, Jacksonville to Lake Harvey	700
Intracoastal waterway, Jacksonville to Miami	8,856
Palm Beach Harbor	10,686
Port Everglades Harbor	34,994
Miami Harbor	24,485
Charlotte Harbor	105,885
Tampa Harbor	4,598,688
St. Mark's River	76,553

TABLE D-2. (Continued)

Port	Total Tons
Florida (cont'd.)	
Apalachicola, Chattaholchee and Flint Rivers, Ga. and Florida	105,327
Port Joe Harbor	17,786
Panama City Harbor	70,448
Escambia & Conecuh Rivers, Fla. & Ala., Escambia Bay	318,768
Pensacola Harbor	116,381
Fernandina Harbor	65,800
Fort Pierce Harbor	12,599
Key West Harbor	617
Gulf Intracoastal Waterway between Apalanchee Bay, Fla. & the Mexican Border (Consolidated Report)	29,142
Gulf County Canal	7,732
Georgia	
Savannah Harbor	515,187
Atlantic Intracoastal waterway between Norfolk, Va. and St. John's River, Fla., (Savannah District)	116,087
Savannah River below Augusta	28,765
Brunswick Harbor	162,194
Atlantic Intracoastal waterway between Norfolk, Va. and St. John's River, Florida	1,628
Hawaii	
Hilo Harbor	64,725
Kahului Harbor, Maui	28,858
Honolulu Harbor, Oahu	161,859
Nawilliwili Harbor, Kauai	19,487
Kaumalapua Harbor, Lanai	2,792
Pearl Harbor, Oahu	51
Kauai	3,042

Port	Total Tons
Illinois	
Illinois River	2,741
Illinois Waterway	3,273,549
Port of Chicago	43,556
Indiana	
Indiana Harbor	92,959
Louisiana	
Innerharbor Navigation Canal	57,836
Mississippi River-Gulf Outlet	385,251
Waterway from Empire to Gulf of Mexico	3,125
Barataria Bay Waterway	564,150
Bayou LaFourche and LaFourche Jump Waterway	529,292
Waterway from Intracoastal Waterway to Bayou Dulac, (Bayou Le Carpe and Grand Calliou)	2,963
Atchafalaya River, Morgan City to Gulf of Mexico	658
Calcasieu River and Pass (Lake Charles)	1,876,942
Bayou Little Cailldu	15
Port of Baton Rouge	3,991,890
Port of New Orleans	8,497,860
Maine	
Penobscot River	812
Searsport Harbor	52,913
Portland Harbor	5,383
Maryland	
Baltimore Harbor and channels	1,359,383
Choptank River	23,130
Nanticoke River, Includ- NW Fork, Del. & Md.	3,086

TABLE D-2. (Continued)

Port	Total Tons
Maryland (cont'd.)	
Wicomico River (eastern shore)	7,393
Pocomoke River	1,840
Harre de Grace	13,975
Potomac River below Washington, D. C.	3,529
Massachusetts	
Salem	--
Port of Boston	151,740
Cape Cod Canal	152,[illegible]50
New Bedford & Fairhaven	606
Fall River Harbor	148,318
Beverly Harbor	18,646
Gloucester Harbor	16
Harbor of Refuge, Nantucket	1,421
Michigan	
St. Mary's River	144,070
Gray's Reef Passage	154,493
Manistique Harbor	2,839
Frankfort Harbor	155,286
Leedington Harbor	379,033
Muskegon Harbor	12,657
Saginaw River	171,406
St. Clair River	276,287
Channels in Lake St. Clair	281,603
Detroit River	374,076
Port of Detroit	98,609
Toledo Harbor	114,455
White Lake Harbor	13,082
Minnesota	
Mississippi River, Minneapolis to Mouth of Passes (Consolidated Report)	5,632,434
Mississippi	
Mouth of Yazoo River	24,987
Yazoo River	12,127
Pascagoula Harbor	1,079,526
Gulfport Harbor	304,198

Port	Total Tons
Montana	
Missouri River, Ft. Benton to the mouth (Consolidated Report)	347,250
New Hampshire	
Portsmouth Harbor	--
New Jersey	
Big Timber Creek	115,200
Muntua Creek	178,244
N.J. Intracoastal Waterway	--
Delaware River, Trenton to sea	3,081,306
Delaware River between Trenton & Phila.	134,306
Delaware River, Phila. to sea	3,000,004
New York	
Port of New York	5,209,113
Hudson River, Deepwater in Upper Bay to Waterford	342,907
Hudson River, Mouth of Spayten Dayvic Cr.	1,218
Federal Lock, Troy	105,082 (Dome)
N.Y. State Barge Canal System	117,154 (Dome)
Hempstead Harbor	--
Huntington Harbor	--
Fire Island, Great S. Bend	--
Northport Harbor	18
Port of Buffalo	55,057
Rochester Harbor	4
Oswego Harbor	62,640
Ogdensburg Harbor	904

TABLE D-2. (Continued)

Port	Total Tons
North Carolina	
Morehead City	278,582
Port of Wilmington	398,907
Wilmington Harbor	434,176
Cape Fear River above Wilmington	5,000
Northeast (Cape Fear) River Waterway connecting Pamlico Sound and Beaufort Harbor Waterway-Norfolk, Va. to Sounds of North Carolina	69,000
Roanoke River	10,042
Neuse River	28,548
Pamlico & Tar Rivers	482,751
Atlantic Intracoastal Waterway between Norfolk, Va. and the St. John's River, Fla. (Charleston District)	37,936
Ohio	
Sandusky Harbor	48
Lorain Harbor	18,000
Cleveland Harbor	31,412
Fairport Harbor	2,561
Ashtabula Harbor	2,524
Oregon	
Port of Portland	380,544
Willamette River above Portland and Yamhill River	3,932
Coos Bay	6,762
Port of Astoria	13,437
Pennsylvania	
Port of Clairton	248,636
Allegheny River, improved portion Ohio River	8,583,205
Eric Harbor	68
Philadelphia Harbor	704,666
Puerto Rico	
Guanica Harbor	165,977
Mayaguez Harbor	165,977
Ponce Harbor	23,806
San Juan Harbor	320,700
Rhode Island	
Providence River and Harbor	74,820
South Carolina	
Charleston Harbor (Including Ashley River, Shem Creek and Shipyard River	386,977
Port Royal Harbor	22
Tennessee	
Cumberland River, Mouth to Mile 552 (Consolidated Report)	198,087
Tennessee River, Tenn., Ala. and Kentucky	1,083,070
Barkley Canal, Cumberland and Tennessee Rivers	189,744
Hiwassee River	38,647
Texas	
Brazos Island Harbor (Brownsville & Port Isabell)	261,970
Channel of Aransas Pass	1,305
Sabine Pass Harbor (Port of Waterway)	2,693
Sabine-Neches Waterway, (Beaumont, Orange, Port Arthur and Sabine Pass Harbor	10,705,105
Houston Ship Channel	8,515,265
Texas City Channel	4,562,262
Galveston City Channel	359,728

TABLE D-2. (Continued)

Port	Total Tons
Texas (cont'd.)	
Freeport Harbor	2,724,695
Matagorda Ship Channel	452,202
Port Aransas-Corpus Christi Waterway (Corpus Christi and Harbor Island)	2,159,491
Vermont	
Narrows of Lake Champlain	--
Burlington Harbor	--
Virginia	
Norfolk Harbor	1,416,815
Hampton Roads	1,557,572
Channel to Newport News	767,817
Port of Newport News (including Newport News Cr.)	110,861
James River (Consolidated Report)	502,826
Atlantic Intracoastal waterway between Norfolk & St. John's River, Fla.	595,448
Atlantic Intracoastal waterway between Norfolk and St. John's River, Fla. (Wilmington District)	680,816
York River	58,539
Rappahannock River	91,648
Virgin Islands	
Christiansted Harbor. St. Croix	2,202
St. Thomas Harbor	2,643
Washington	
Columbia River, Mouth to International Boundary (Consolidated Report)	860,737

Port	Total Tons
Washington (cont'd.)	
Columbia and Lower Willamette Rivers below Vancouver, Wash. & Portland, Oregon	860,737
Port of Longview	97,660
Port of Kalama	41,522
Port of Vancouver	402,325
Columbia River between Vancouver & The Dalles, Ore.	45,452
Lake River	150
Grays Harbor and Chehalis River	523
Port Angeles Harbor	36,810
Tacoma Harbor	639,310
Seattle Harbor	150,396
Lake Washington Ship Canal	1,030
Everett Harbor and Snohomish River	58,344
Anacortes Harbor	78,388
Bellingham Bay & Harbor	172,355
Nonproject - Other Puget Sound Area Ports	295,266
West Virginia	
Kanawha River	4,184,533
Little Kanawha River	145,103
Monongahela River, Pa. & W. Va.	613,657
Big Sandy River, Tug & Levisa Forts, Ky. & W. Va.	97,605
Wisconsin	
St. Croix River, Wis. & Minnesota	1,000
Minnesota River	84,539
Menominee Harbor & River, Mich. & Wis.	14,152
Green Bay	11,128
Sturgeon Bay & Lake Michigan Canal	14,152
Kewaunee Harbor	64,783
Manitowoc Harbor	259,393
Milwaukee Harbor	315,110
Detroit Harbor	128
Kenosha Harbor	160

TABLE D-3. Production Indexes,(57) (1957-59=100)

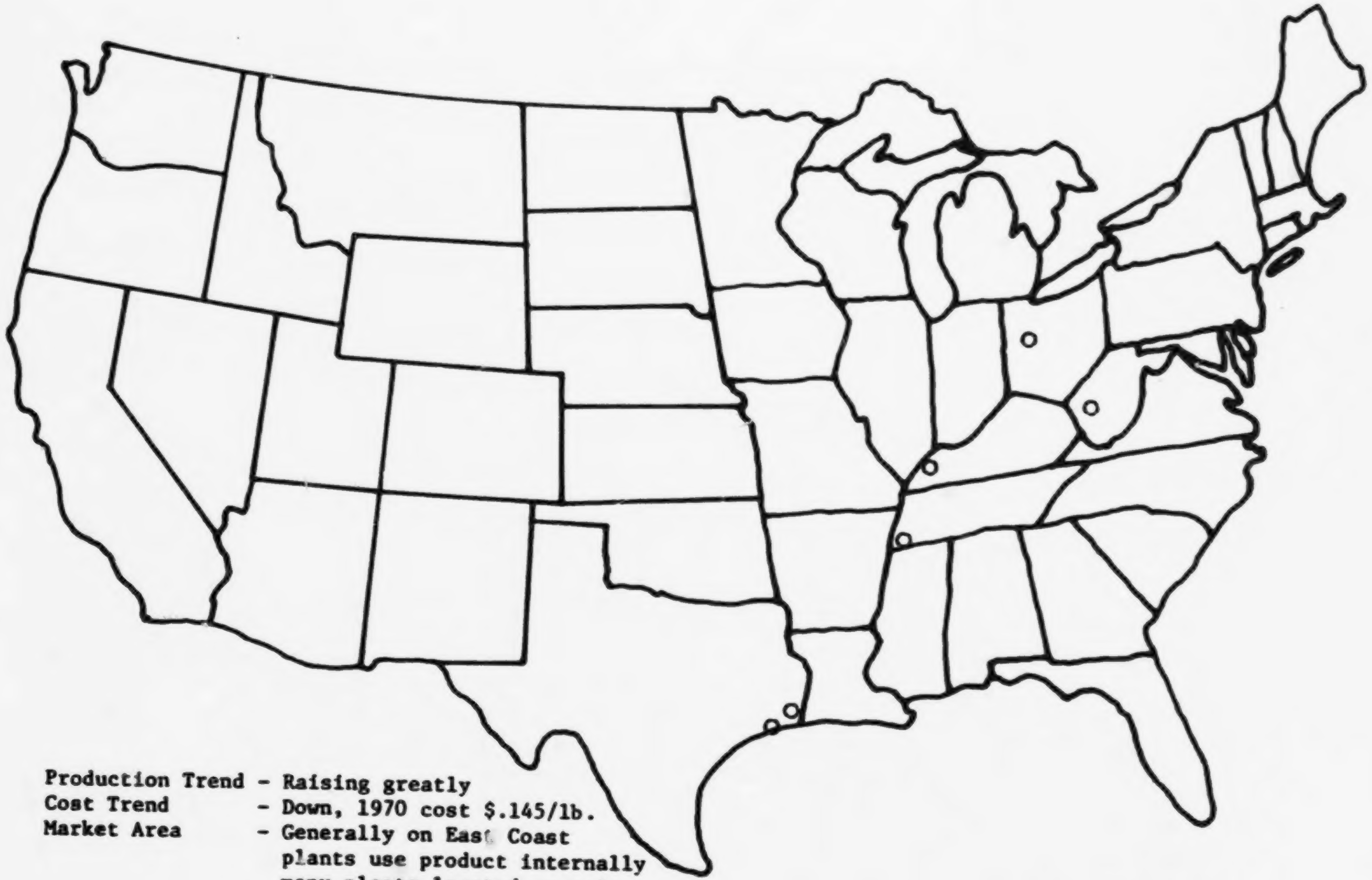
	1967	1968	1969a	1970b
Chemicals and Products	203.8	221.7	239.0	242
Industrial chemicals	236.0	262.0	283.0	285
Basic inorganic chemicals	237.4	249.5	263.0	276
Basic organic chemicals	216.2	226.8	233.9	228
Plastic materials	348.6	401.5	468.1	475
Synthetic rubber	161.6	179.5	188.2	190
Man-made fibers	281.9	365.4	398.9	408
Soap and related products	149.0	156.7	162.0	163
Paints	120.4	129.2	135.9	128
Fertilizer	139.8	134.1	132.1	135

a Preliminary
b C&EN estimates

TABLE D-4. Wholesale Price Indexes(57)

	1967	1968	1969	1970a
Chemicals and Allied Products	98.4	98.2	98.3	100
Industrial chemicals	97.4	98.4	97.7	98
Drugs and pharmaceuticals	94.0	93.3	93.8	95
Fats and oils, inedible	81.3	73.9	88.7	105
Plastic resins and materials	89.0	81.8	80.7	80
Agricultural chemicals and chemical products	103.6	99.6	89.8	92
Prepared paint	109.3	114.6	119.2	123
Paint materials	90.9	92.2	92.8	92
Other chemicals and allied products	108.3	110.0	112.9	117

a C&EN estimates

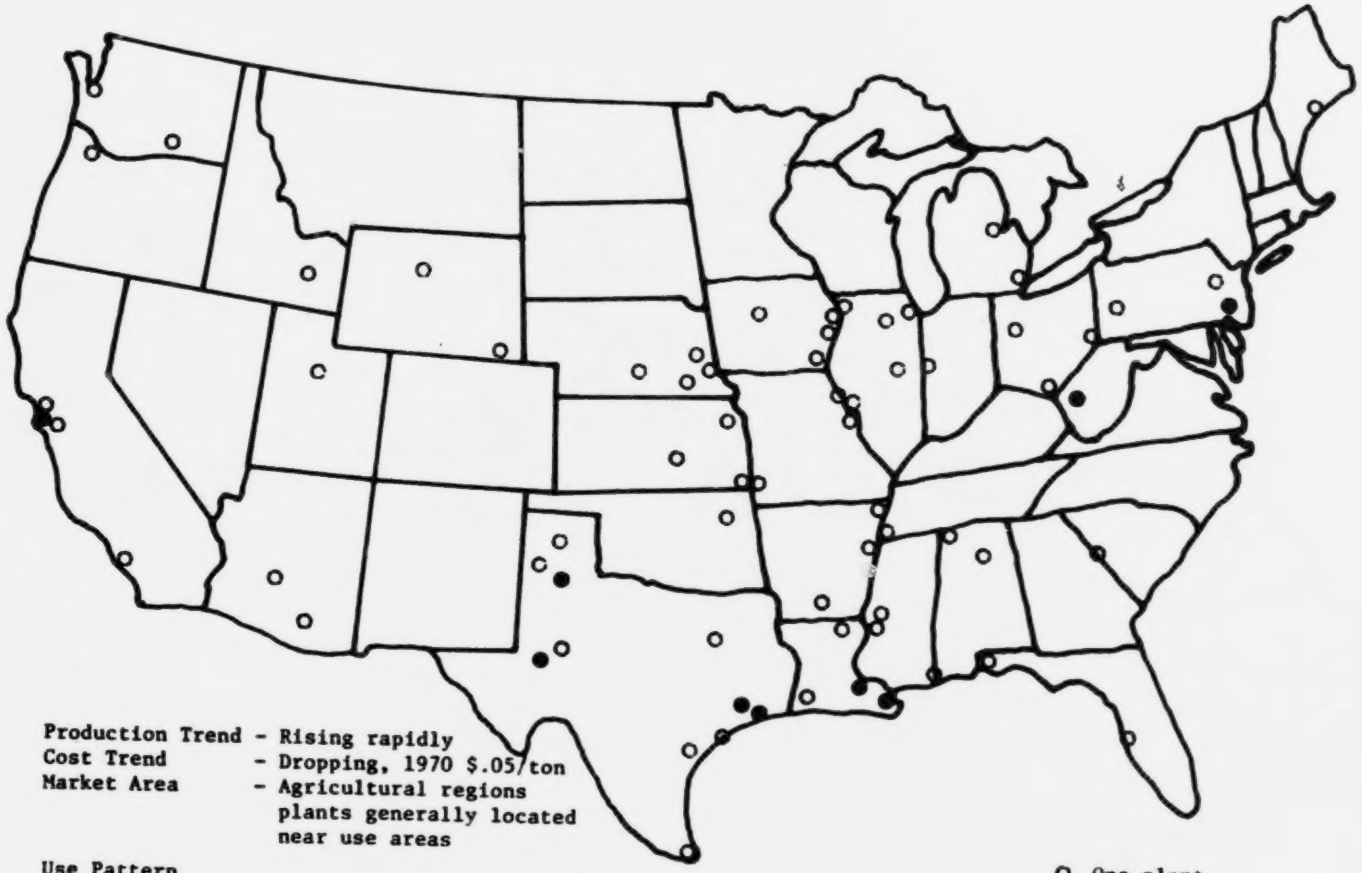


Production Trend - Raising greatly
Cost Trend - Down, 1970 cost \$.145/lb.
Market Area - Generally on East Coast plants use product internally many plants located on main river arteries

Use Pattern

	Per Cent
Acrylic fibers	52
ABS resins	10
Nitrile rubber	8
Miscellaneous and export	30
	100

FIGURE D-1. Acrylonitrile Production Sites(28)

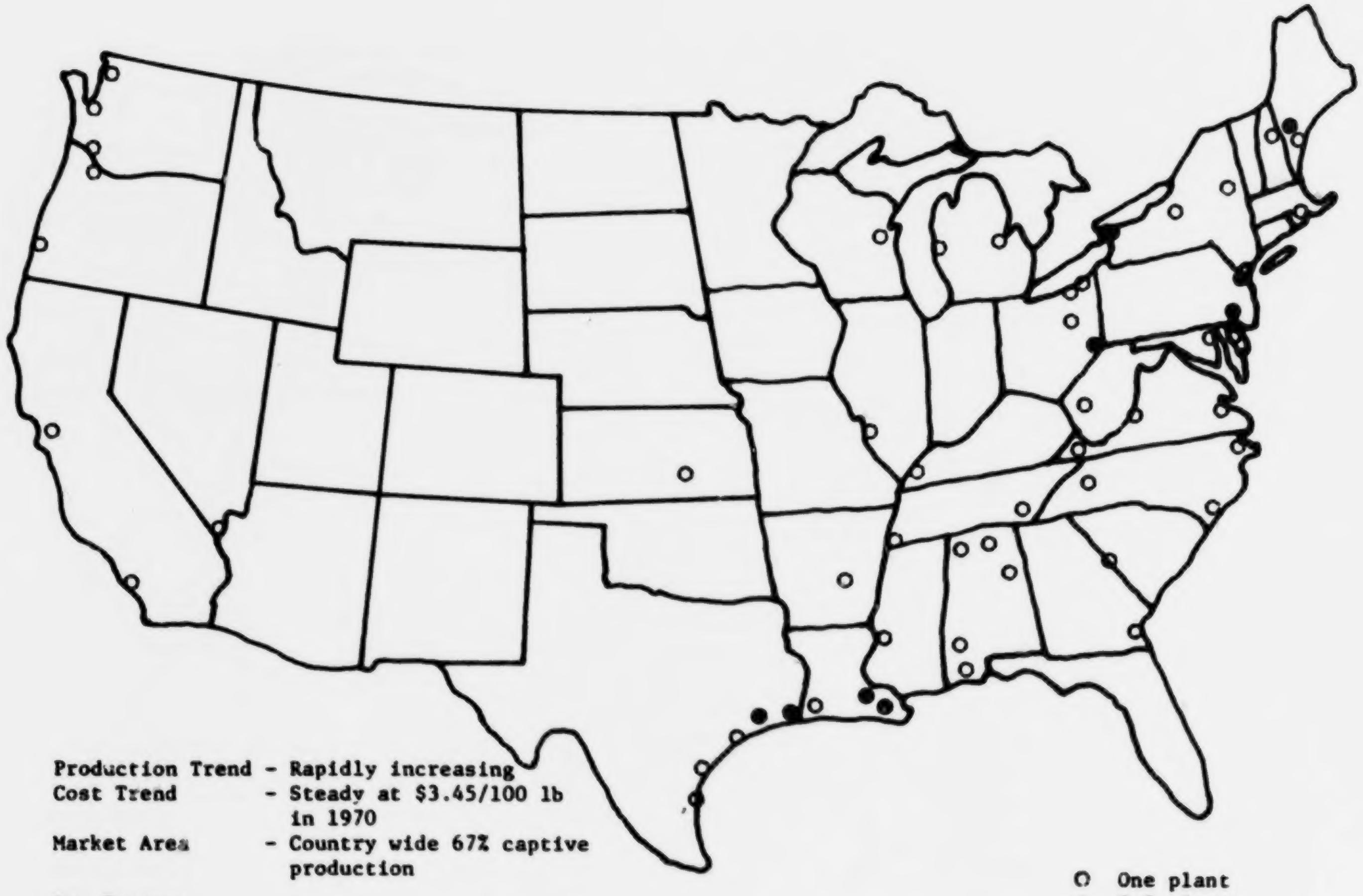


Production Trend - Rising rapidly
Cost Trend - Dropping, 1970 \$.05/ton
Market Area - Agricultural regions plants generally located near use areas

Use Pattern

	Per Cent
Fertilizer	78
Industrial and military	22
	100

FIGURE D-2. Ammonia Production Sites (28)

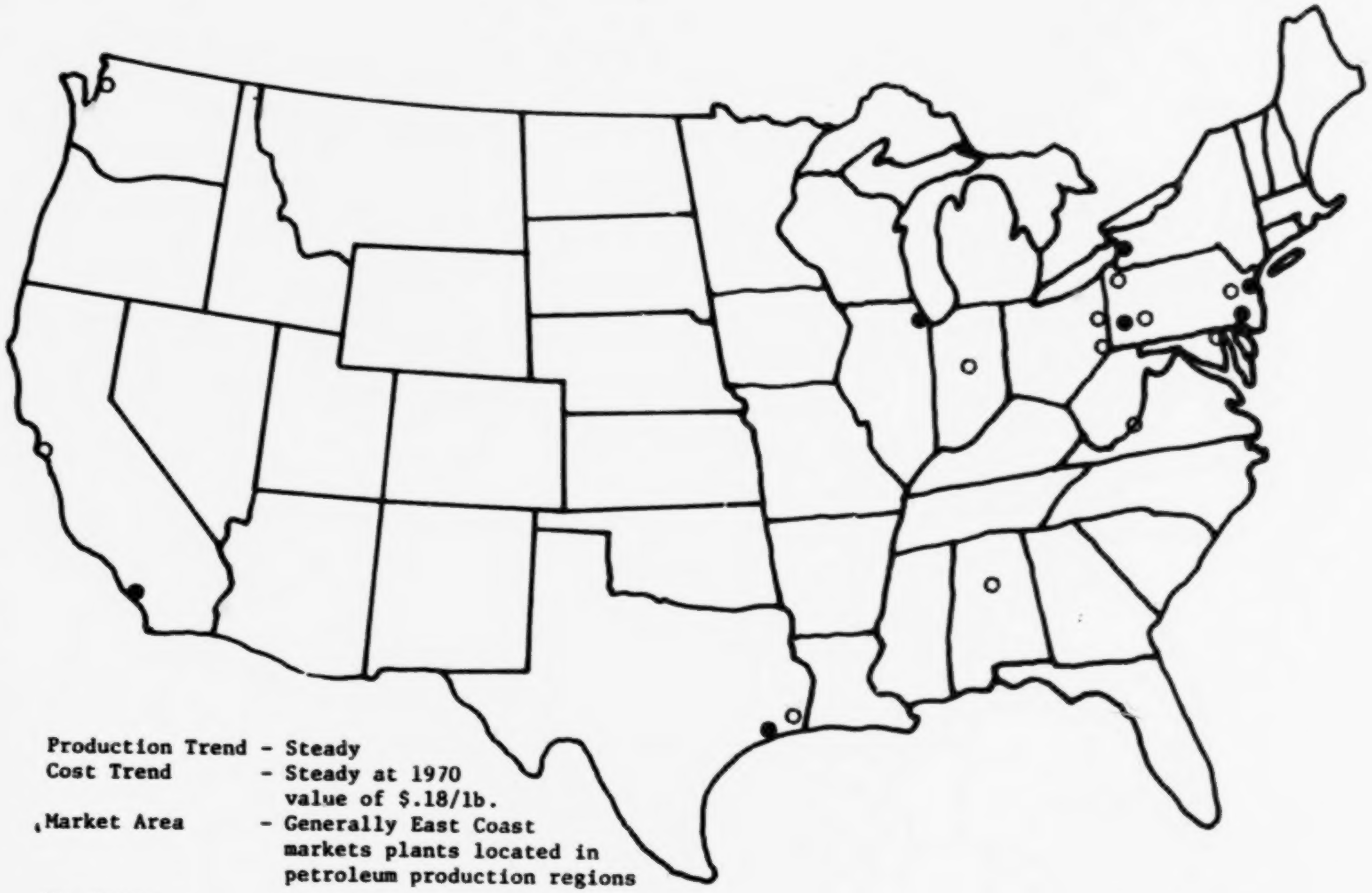


Production Trend - Rapidly increasing
Cost Trend - Steady at $3.45/100 lb in 1970
Market Area - Country wide 67% captive production

Use Pattern

	Per Cent
Organic chemicals	65
Pulp and paper	17
Inorganic chemicals	9
Water and sewage	4
Miscellaneous	5
	100

FIGURE D-3. Chlorine Production Sites(28)

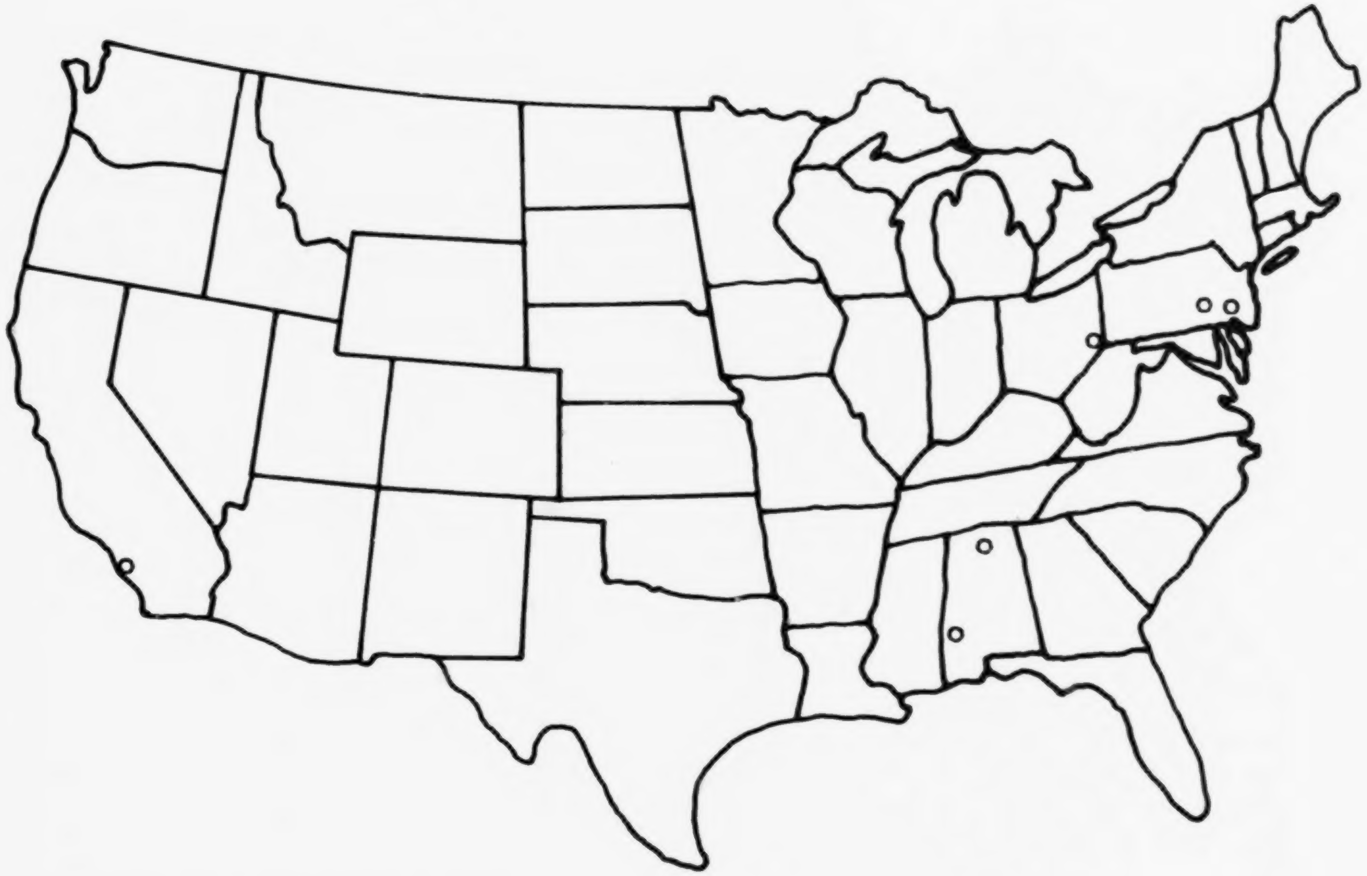


Production Trend - Steady
Cost Trend - Steady at 1970 value of $.18/lb.
Market Area - Generally East Coast markets plants located in petroleum production regions

Use Pattern

	Per Cent
Phenolic resins	50
Phosphate esters	28
Wire enamel solvents	7
Ore flotation	3
Metal cleaning	2
Miscellaneous and export	10
	100

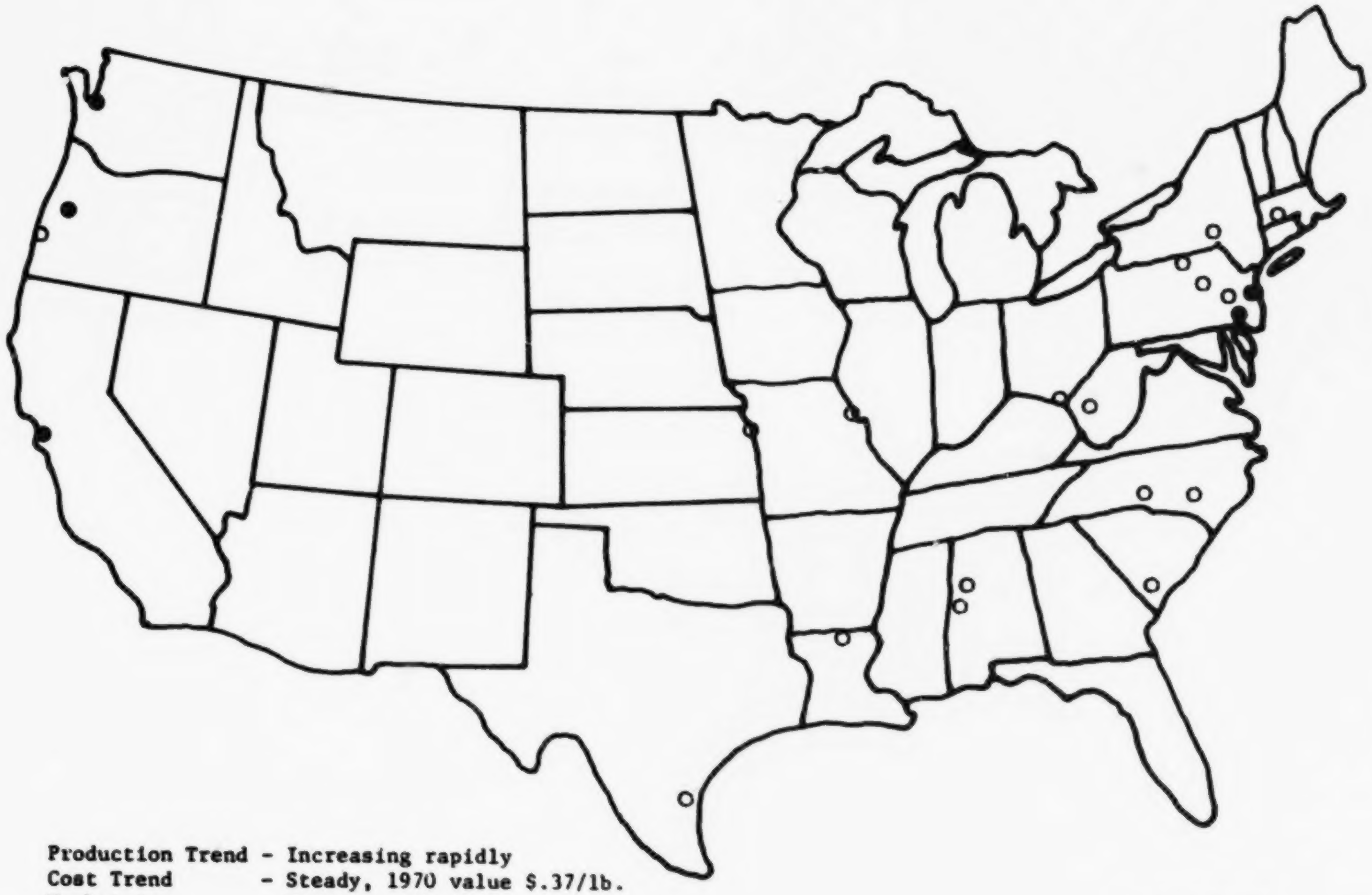
FIGURE D-4. Cresol Production Sites[28]



Production Trend - Beginning to drop
Cost Trend - Cost rising, 1970 value $.22/lb.
Market Area - Agricultural regions widespread transport of product production economics presently in doubt

Use Pattern
Insecticide and miticide 100%

FIGURE D-5. DDT Production Sites(28)

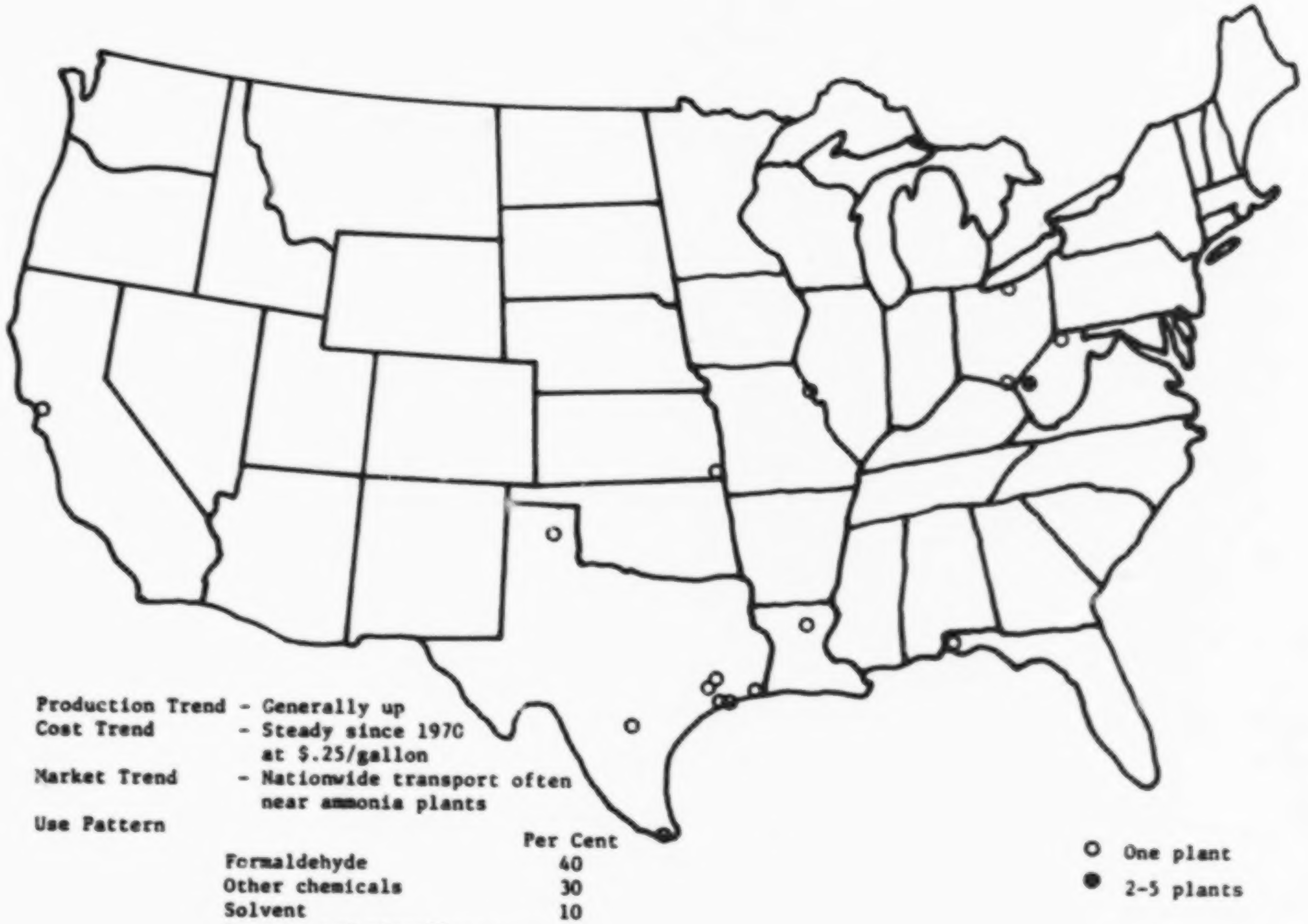


Production Trend - Increasing rapidly
Cost Trend - Steady, 1970 value $.37/lb.
Market Area - Eastern markets

Use Pattern

	Per Cent
Resins	60
Pentaerythritol	9
Ethylene glycol	12
Hexamethylenetetramine	5
Miscellaneous	14
	100

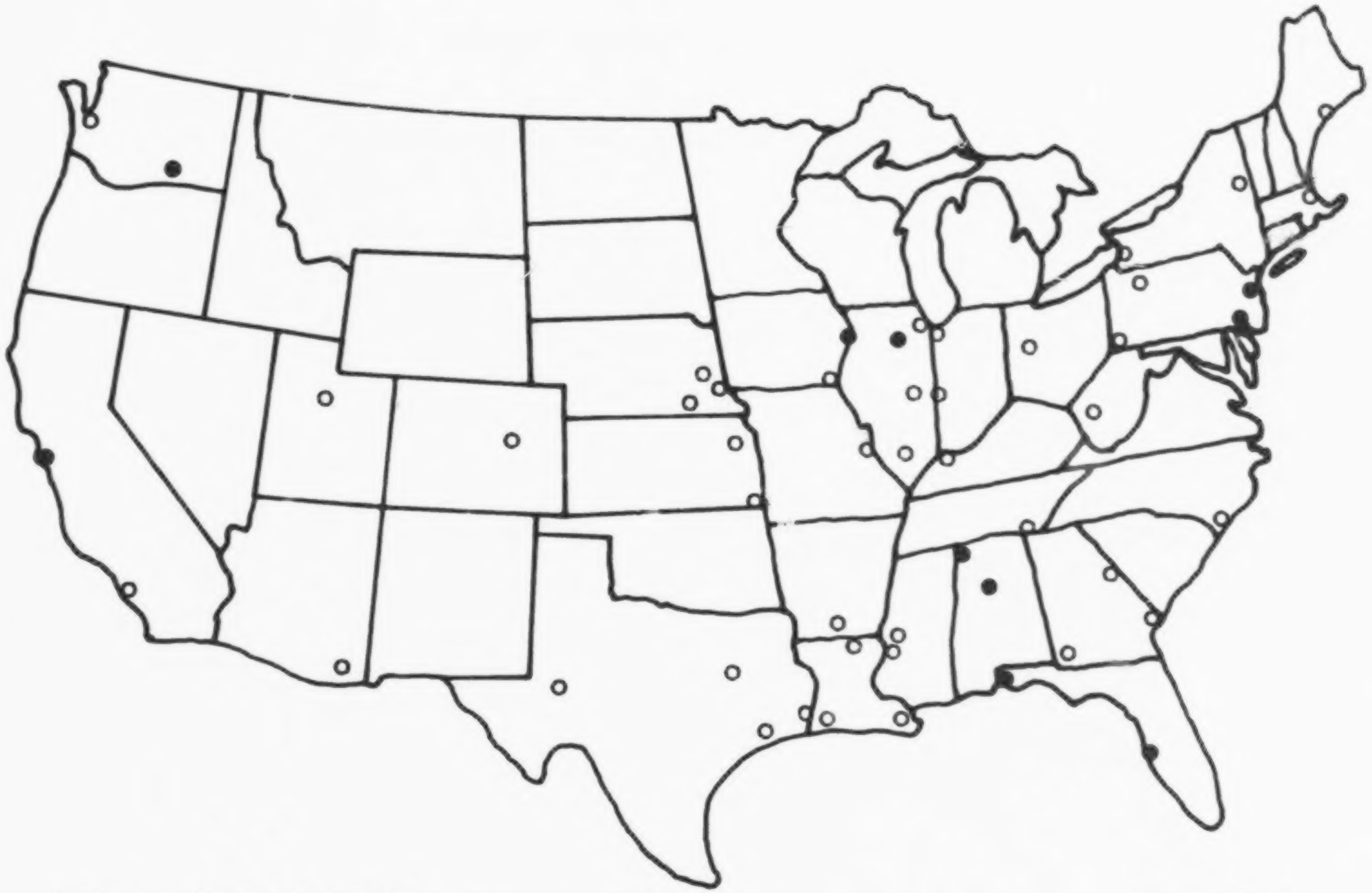
FIGURE D-6. Formaldehyde Production Sites[(28)]



Production Trend - Generally up
Cost Trend - Steady since 1970 at $.25/gallon
Market Trend - Nationwide transport often near ammonia plants
Use Pattern

	Per Cent
Formaldehyde	40
Other chemicals	30
Solvent	10
Exports and miscellaneous	20
	100

FIGURE D-7. Methyl Alcohol Production Sites[28]

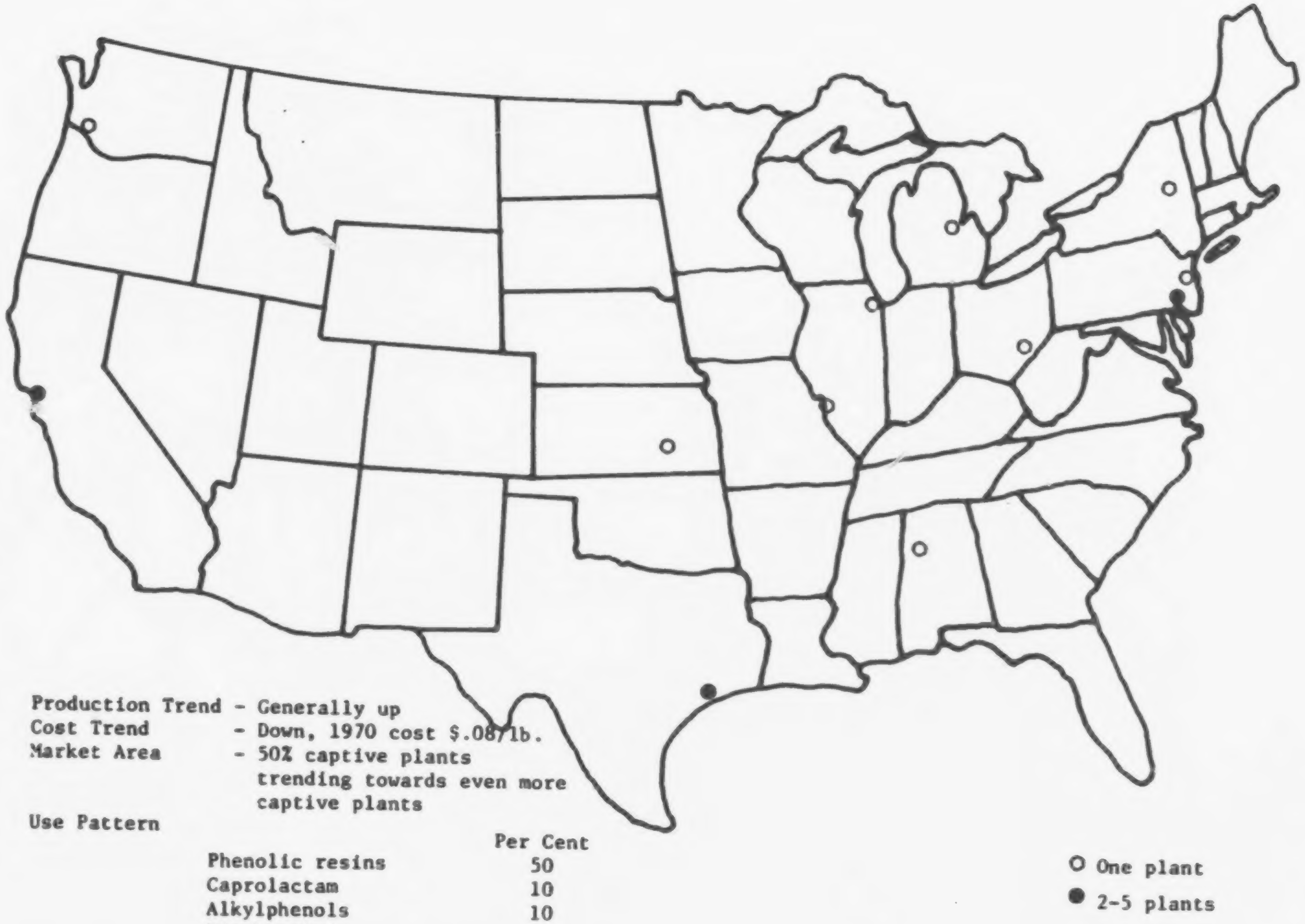


Production Trend - Up sharply
Cost Trend - Steady at 1970 value of $5.40/hundred wt.
Market Area - Mostly inter-plant shuttling

Use Pattern

	Per Cent
Fertilizer	75
Explosives	15
Miscellaneous (chemicals, etc.)	10
	100

FIGURE D-8. Nitric Acid Production Sites (28)

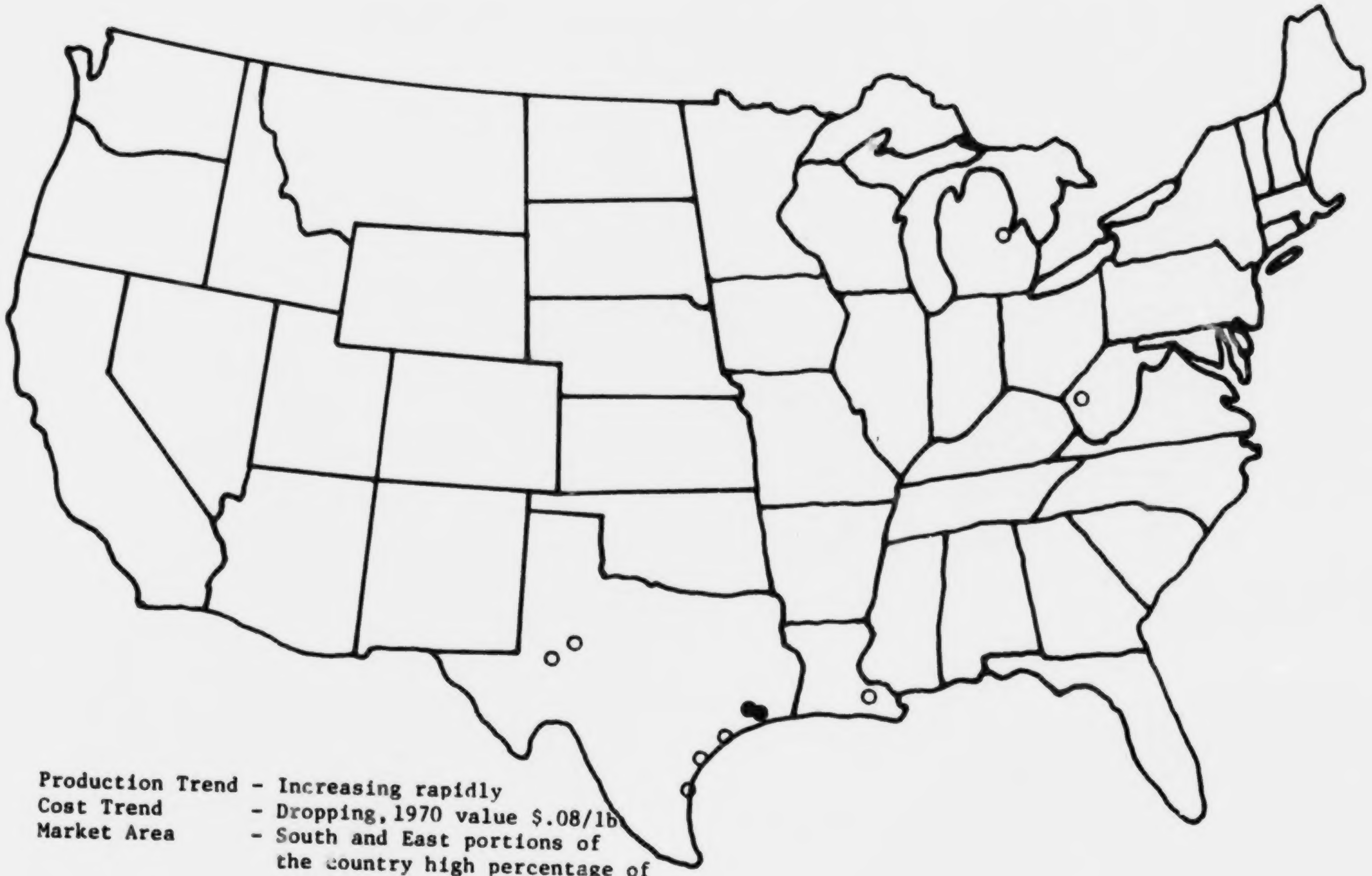


Production Trend - Generally up
Cost Trend - Down, 1970 cost $.08/lb.
Market Area - 50% captive plants trending towards even more captive plants

Use Pattern

	Per Cent
Phenolic resins	50
Caprolactam	10
Alkylphenols	10
Bisphenol-A	7
Miscellaneous and export	23
	100

FIGURE D-9. Phenol Production Sites(28)



Production Trend - Increasing rapidly
Cost Trend - Dropping, 1970 value \$.08/lb
Market Area - South and East portions of the country high percentage of captive plants

Use Pattern

	Per Cent
Polystyrene	50
S-B rubber	25
Latexes	7
Polyesters	4
Styrene copolymers	2
Miscellaneous and export	12
	100

FIGURE D-10. Styrene Production Sites (28)

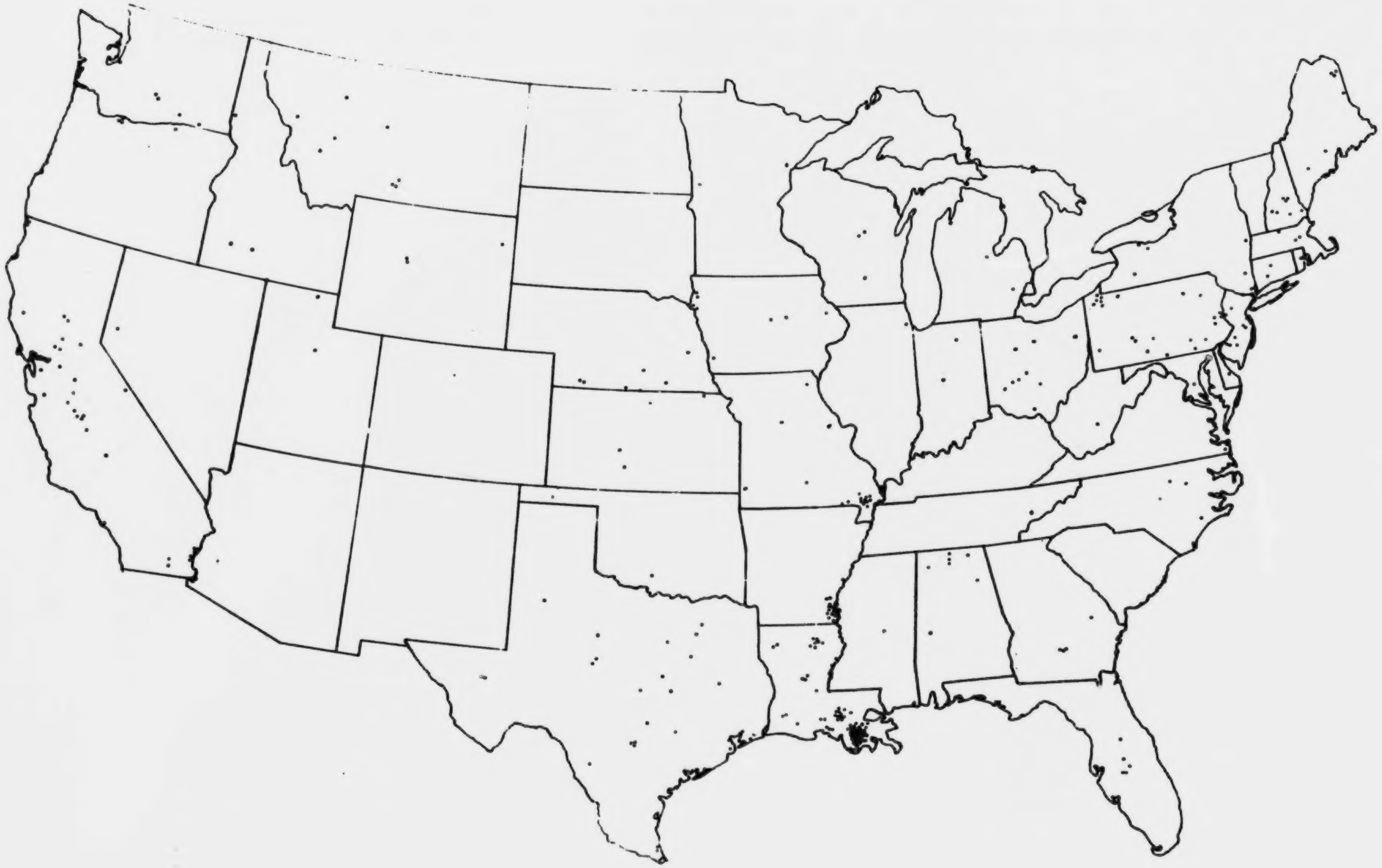


FIGURE D-11. Geographical Distribution of Pesticide Caused Fish Kills 1963 - 1968 References (30) (65-69)

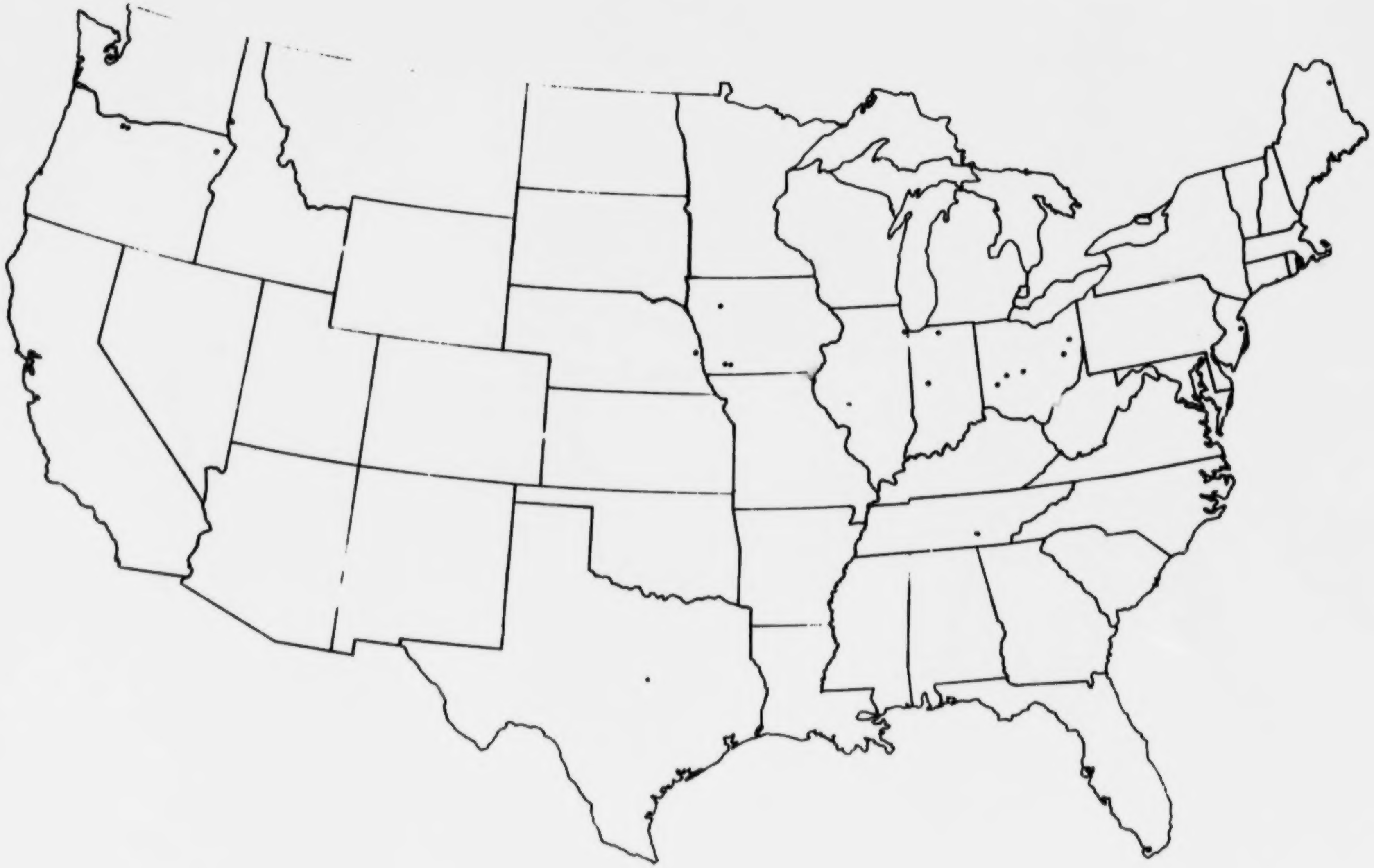


FIGURE D-12. Geographical Distribution of Fish Kills Originating from Fertilizer Materials 1963 - 1968 References (30) (65-69)

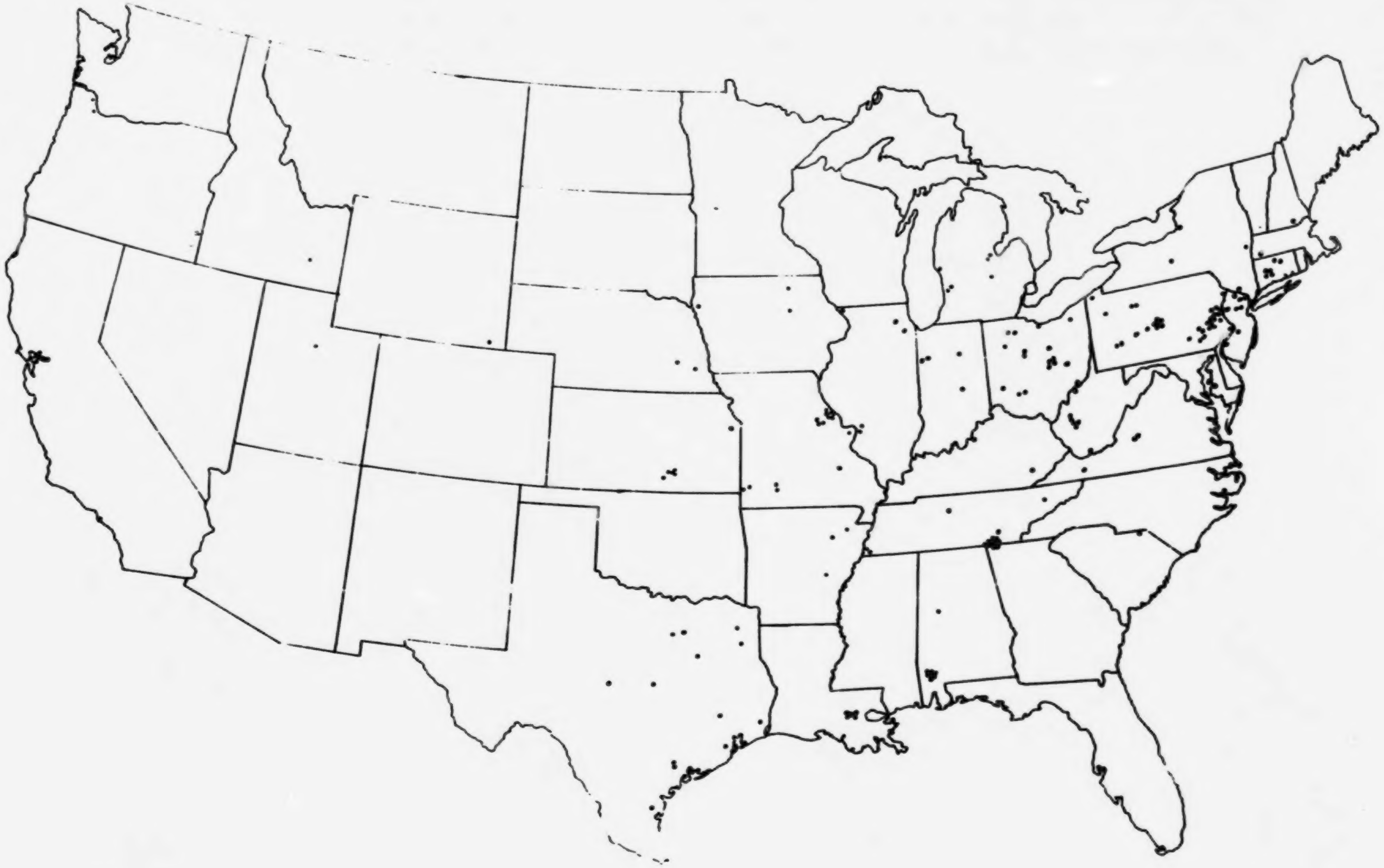


FIGURE D-13. Geographical Distribution of Fish Kills Originating from Chemical Plants 1960 - 1968
References (30) (63-69) (76)

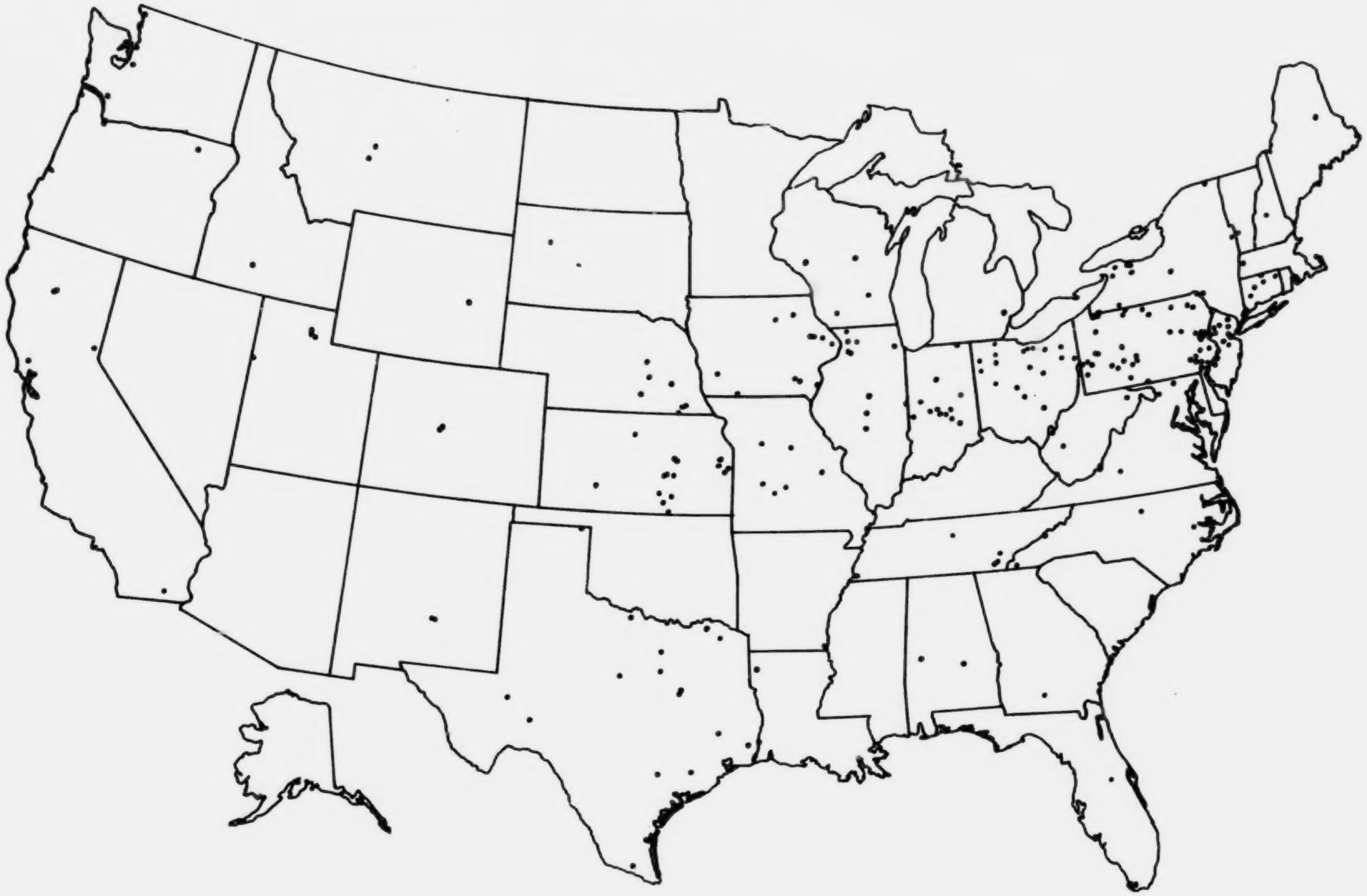


FIGURE D-14. Geographical Distribution of Fish Kills Originating from Transportation Activities 1960 - 1968 References (30) (63-69) (76)

TABLE D-5. Fish Kills Resulting from Pesticides(30)(65-69)

Year	Number of Reports	Total Kill Reported	Average Kill of Incidents Reporting Kill Totals
1963	60	401,415	10,849
1964	93	191,167	2,583
1965	74	770,557	12,039
1966	51	217,406	4,941
1967	43	329,130	7,654
1968	51	325,194	7,742

TABLE D-6. Fish Kills Resulting from Fertilizer Compounds(30)(65-69)

Year	Number of Reports	Total Kill Reported	Average Kill of Incidients Reporting Kill Totals
1963	3	1,400	700
1964	5	67,040	16,760
1965	4	2,697	674
1966	1	1,200	1,200
1967	2	10,000	5,000
1968	5	15,116	3,023

TABLE D-7. Frequency Distribution of Reported Critical Duration for Agricultural Spills(30)(63-69)(76)

Duration in Days	1960	1961	1962	1963	1964	1965	1966	1967	1968
<1	6	--	--	3	7	6	5	5	4
1	29	32	2	18	45	37	19	11	14
2	18	7	3	17	33	18	25	17	12
3	6	2	1	10	14	11	8	9	9
4	--	1	2	1	2	3	--	4	4
5	3	--	--	2	4	2	1	3	3
6	--	1	--	1	1	1	--	--	--
7	--	1	--	1	2	--	2	--	2
8	--	--	--	--	--	--	--	1	--
9	--	1	--	--	--	--	1	--	--
10	1	1	--	1	--	3	1	--	1
12	--	--	--	--	--	1	--	1	--
14	--	--	1	1	1	--	--	1	1
16	--	--	--	--	--	--	--	--	--
18	--	1	--	1	--	--	--	--	--
20	--	--	--	--	--	--	--	--	--
25	--	--	--	--	--	--	--	--	--
30	--	--	--	1	--	--	--	1	1
35	--	--	--	--	--	--	--	--	--
40	--	--	--	--	--	--	--	--	--
50	--	--	--	--	--	--	--	--	--
60	--	--	--	--	--	--	--	--	--
Average Duration in Days	1.81	2.26	3.67	3.23	2.04	2.22	2.19	3.25	3.29

TABLE D-8. Average Fish Kill Reported by Transport Mode(30)(65-69)

	1963	1964	1965	1966	1967	1968
Truck	11,983	1,295	8,828	5,972	3,866	1,201
Rail	5,000	1,342	700	2,132	4,317	34,242
Barge	--	250	1,025	--	26,750	204
Pipeline	496	1,188	39,484	3,450	3,810	48,508

TABLE D-9. Percentage of Transportation Spill Related Reports Classified by Severity of Damage(30)(65-69)

	All Reports	Total Kill	Heavy Kill	Moderate Kill	Light Kill
1963	100	6.2	37.5	12.5	43.8
1964	100	3.8	26.9	26.9	38.6
1965	100	11.1	29.7	25.9	22.2
1966	100	22.2	11.1	29.7	18.5
1967	100	9.1	45.4	27.3	18.2
1968	100	10.2	46.2	7.7	7.7

TABLE D-10. Yearly Data on Transportation Spill Related Fish Kills(30)(65-69)

Year	Number of Reports	Number of Reports with Fish Kill Totals	Total Fish Killed	Average Fish Killed	Est. Fish Killed	Relative Rank of Average Kill Compared to Other Causes	Total Reports by Transport Mode Rail	Truck	Barge	Pipeline
1963	17	10	78,388	7,840	133,000	2	2	8	1	6
1964	26	18	22,211	1,235	32,000	4	5	10	1	10
1965	27	21	306,810	7,995	355,000	1	6	12	3	6
1966	27	24	102,631	4,275	116,000	5	6	11	3	7
1967	22	19	143,123	7,535	166,000	2	4	7	3	8
1968	39	33	825,365	9,155	880,000	1	10	5	9	15

TABLE D-11. Frequency Distribution of Reported Critical Duration for Transportation Spill Related Fish Kills(30)(65-69)

Duration in Days	1963	1964	1965	1966	1967	1968
<1	1	3	4	7	2	1
1	3	5	4	2	5	8
2	4	8	2	4	--	4
3	2	1	3	3	4	2
4	1	1	3	1	--	2
5	1	--	--	2	1	2
6	--	--	--	1	--	2
7	--	--	--	--	--	1
8	--	--	--	--	--	--
9	--	--	--	--	--	--
10	--	1	--	1	--	1
12	1	--	1	--	--	--
14	--	--	2	--	--	1
16	--	--	--	1	--	--
18	--	--	--	--	--	--
20	--	--	--	--	--	--
25	--	--	--	--	--	--
30	--	--	--	--	--	--
35	--	--	--	--	--	--
40	--	--	--	--	--	--
50	--	--	--	--	1	--
60	--	--	--	1	--	--
Average Duration in Days	3.00	2.16	3.84	5.74	5.69	3.50

TABLE D-12. Fish Kills Resulting from Chemical Plant Releases(30)(65-69)

Year	Number of Reports	Total Kill Reported	Average Kill of Incidents Reporting Kill Totals
1963	34	224,441	7,739
1964	26	525,739	20,220
1965	37	218,661	7,053
1966	36	708,815	19,689
1967	24	43,732	1,987
1968	39	731,881	18,766

TABLE D-13. Number of States Reporting Fish Kills(69)

Year	1960	1961	1962	1963	1964	1965	1966	1967	1968
Number of States	36	45	37	38	40	44	46	40	42

ILLINOIS AND CALIFORNIA SPILLS

Hazardous chemical spills occur anywhere and everywhere along the production-market chain. They can result from mishandling in the production plant, improper loading procedures, transportation leaks or accidents, storage facility failures, improper unloading procedures, careless application, improper container disposal, or intentional dumping. The great number of possible causes and the probable location of spills occurring from those causes demonstrate the fact that while any area may be subjected to hazardous material spills, the frequency of those spills will not necessarily be related to the density of chemical industry plants in that area.

Figure D-15 illustrates a case where spills are occurring at the point of application. Figure D-16 shows a relative density map of chemical production for each county in California,(82) while Figure D-15 uses a similar shading scheme to show the density of reported fish kills in the same California counties from 1965 to 1969.(29) The two maps do not appear to have a direct relationship. Perhaps a far better correlation can be made in comparing the fish kill incidents to areas of high agricultural use patterns. This is borne out by the fact that most of the spilled contaminants were reported to be pesticidal or fertilizer compounds. In this case, the mode of application and the frequent lack of adequate equipment causes spills at the user end of the chain.

Conversely, fish kill reports from Illinois reflect the susceptibility of areas along transport routes. Figure D-17 shows reported fish kill incidents in the State of Illinois from February 1969 through May 1970.(47) It also shows the general location of transport routes from Springfield, Illinois and St. Louis, Missouri to Cincinnati, Ohio and from Chicago, Illnois to Cedar Rapids, Iowa. Also included are the two major navigable water courses, the Mississippi and Illinois Rivers.

This map illustrates that transport routes are subject to spills resulting from accidents as well as releases from plants that have developed along transport routes. A survey of the compounds identified reveals that the majority are not agricultural chemicals as in California, but industrial chemicals such as benzene and phenol. Neither of the two maps includes gasoline or oil spills.

The contrasting conclusions drawn from these two examples are in fact complementary. They illustrate that spills can occur at the plant, along the transport route, or at the point of use. Consequently, preventive action must focus on the entire flow route of hazardous materials and not merely on any one or two specific links in the chain

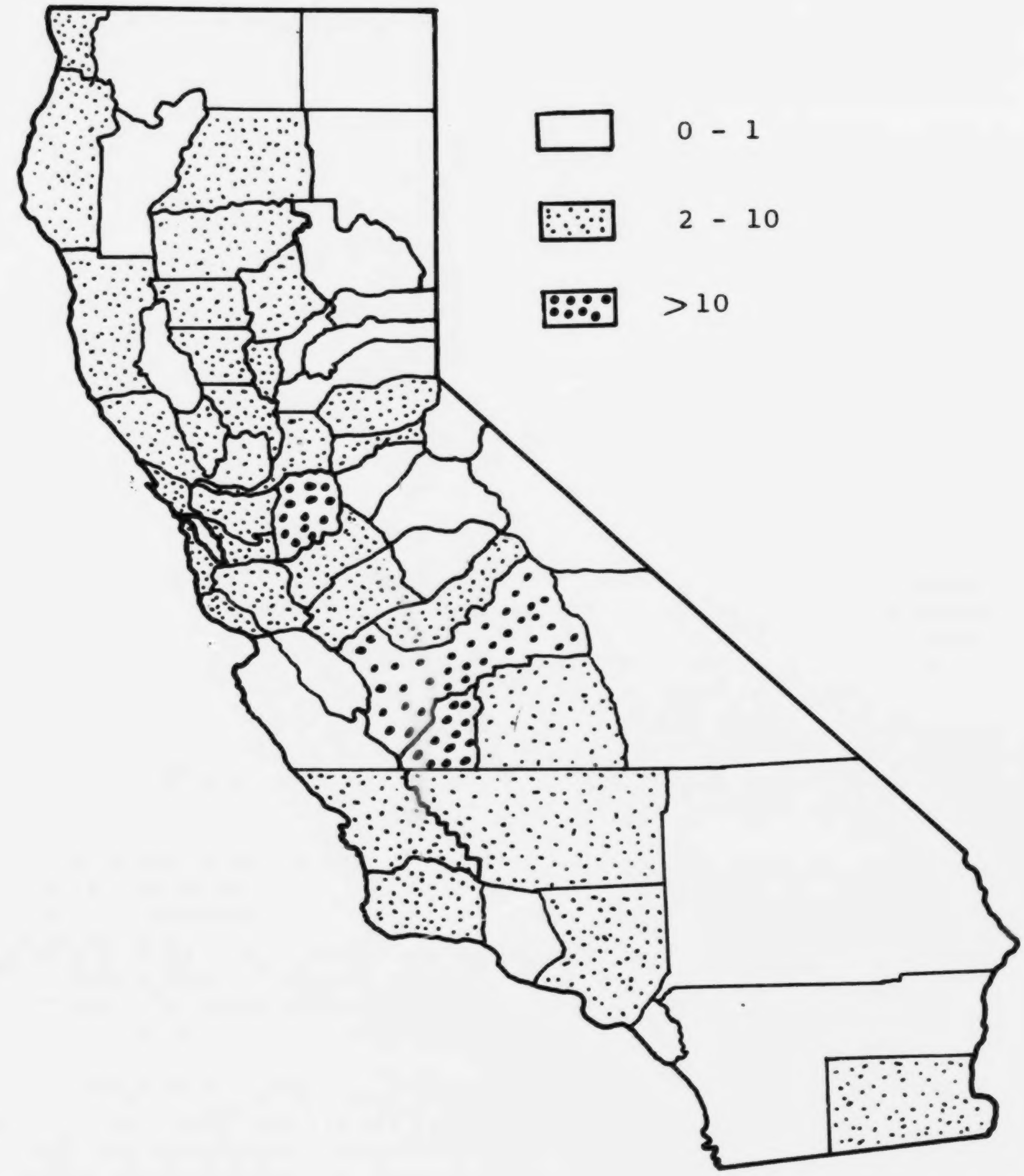


FIGURE D-15. Distribution of Pesticide and Pollution Caused Fish Kills in the State of California by County(29)

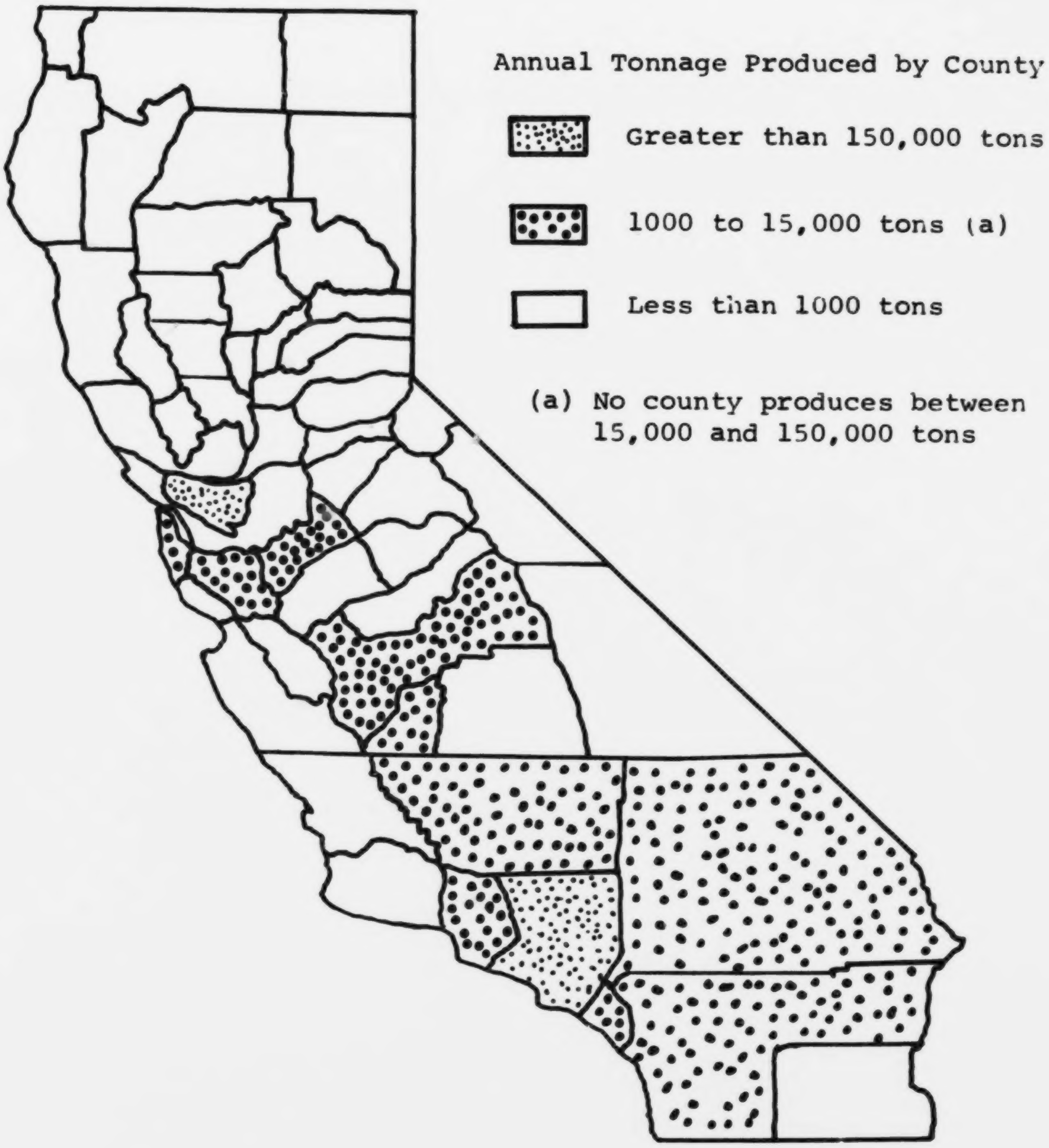

Annual Tonnage Produced by County
Greater than 150,000 tons
1000 to 15,000 tons (a)
Less than 1000 tons
(a) No county produces between 15,000 and 150,000 tons

FIGURE D-16. Distribution of Chemical and Petroleum Industry Wastes, 1967 - State of California (Taken from "Selected Problems of Hazardous Waste Management in California.")(82)

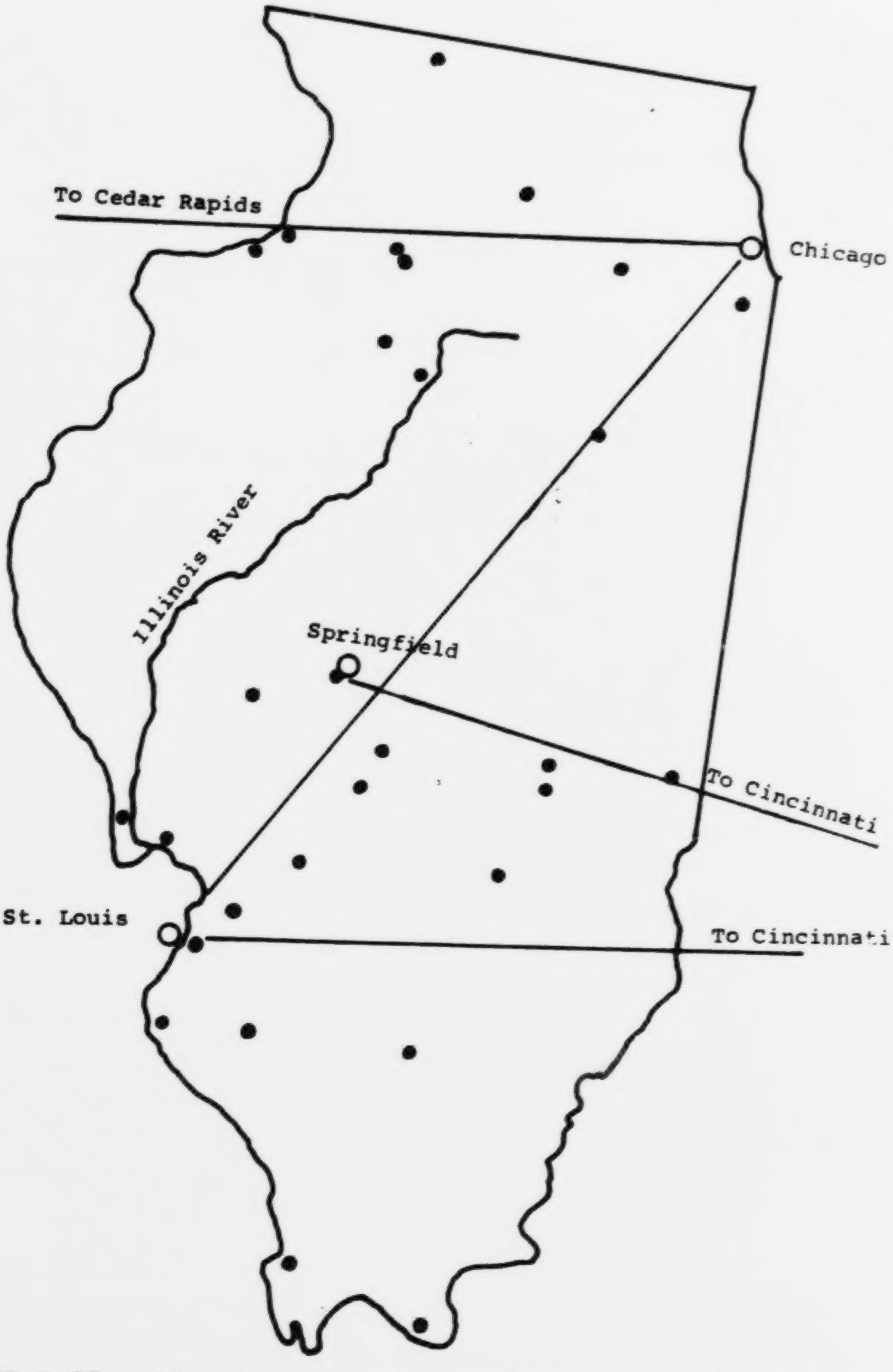


FIGURE D-17. Distribution of Hazardous Chemical Spills in Illinois and Major Transport Routes.(47)

APPENDIX E

POSSIBLE COUNTERMEASURES FOR SOLUBLE COMPOUNTS

The section contains an alphabetical listing of all compounds listed as soluble in the Priority Ranking System and the suggested procedures for neutralizing their damaging effects. The techniques suggested are not necessarily technically feasible at this time, nor is there any guarantee that they will not have effects on the environment of equal or greater severity than the original contaminant. The discussion of response procedures in the text applies to the following suggestions. Similarly, the response code given in the Appendix A printout section follows the steps outlined here. A "z" in the response code of the computer printout signifies that the countermeasure is considered adequate and feasible at this time with the possible exception of situations where a precipitated sludge might cause problems.

Acetaldehyde (Ethanal, acetic aldehyde, ethyladehyde)
Miscible with water - powdered carbon treatment with removal of carbon might be attempted.

Acetic acid
Treat water with $NaHCO_3$ to reduce acidity - dilute.

Acetone (Dimethyl ketone)
Miscible with water - powdered carbon treatment and/or dilution only possibilities for water.

Acetone Cyanohydrin (α - hydroxyisobutryonitrile)
Danger from HCN gas generation - treat contaminated water with $NaHCO_3$ or $Ca(OH)_2$ to maintain high pH and suppress HCN - or precipitate CN^- with Fe^{+3} or chlorinate.

Styrene (Styrol, styrolene, vinyl benzene)
Only sparingly soluble in water - density - 0.90, therefore it floats on water for most part - could probably be removed with available oil spill equipment - powdered charcoal treatment for contaminated water may be possible.

Acetonitrile (Methyl cyanide, cyanomethane)
Density - 0.77 at 30°C - miscible with water - Flash point = 55°C - HCN generation hazard - add $NaHCO_3$ to contaminated water to suppress HCN formation - treat with powdered charcoal to remove CH_3CN from water - also can precipitate CN^- with Fe^{+3} or degradation by chlorination.

Acetophenone (Hypnone, phenyl methyl ketone)
Slightly water soluble - usually liquid - mp = 20.5°C - density = 1.033 - probably would sink to bottom - bottom recovery required - powdered carbon treatment for water soluble fraction if possible.

Acid, Acylhalides and anhydrides
Some are violently decomposed by contact with water - acid and chlorine are the decomposition products - powdered carbon treatment of contaminated water might be attempted.

Acrylic Acid (propenoic acid, vinylformic acid)
Miscible with water - corrosive, heavy liquid - polymerizes readily in the presence of oxygen - add $NaHCO_3$ to raise pH - possibly adsorb on powdered carbon.

Acrylonitrile (propenenitrile, vinyl cyanide, cyanoethylene)
CO_2 from air is enough to liberate HCN gas. Treat contaminated water with $Ca(OH)_2$ immediately to prevent HCN generation - or precipitate CN^- form with Fe^{+3} or chlorinate.

Misc. Acyclic Insecticides
Many are only slightly water soluble - float on water - skimming may be necessary - powdered carbon treatment to remove water soluble remainder might be attempted.

Adipic acid (Hexanedioic acid)
100 ml of saturated water contains 1.44g at pH 2.7 - Recover solid from bottom-adsorb dissolved material on powdered carbon and recover, if feasible - add $NaHCO_3$.

Aldehydes and Ketones
All aldehydes heavier than pentanal (C_4H_9CHO) are water insoluble - the ketones heavier than diethyl ketone ($CH_3CH_2COCH_2CH_3$) are only sparingly water soluble - acetone is the most water soluble - ketones light liquids - floating on water - skimming indicated in some cases - insoluble aldehydes also float on water - treatment of water soluble aldehydes is described under formaldehyde and acetaldehyde.

Aldrin - Toxaphene Group (Octalene - chlorinated camphene group)
Ordinarily nearly water insoluble - can be formulated as oil emulsion or wettable oil emulsion, skimming recovery equipment needed - as wettable dust, desedimentation needed (polyelectrolyte and powdered carbon + alum). Toxaphene is a waxy solid that dehydrochlorinates in the presence of alkali.

Aluminum fluoride
Sparingly soluble in water - 0.6g/100 ml - treat contaminated water with $Ca(OH)_2$ to bring down CaF_2 - pH of water can then be adjusted with soda.

Aluminum sulfate
Treat contaminated water with $NaHCO_3$ to insure precipitation of aluminum hydroxide.

Amines, total
Lower members of the series, to hexylamine, are very soluble in water - aromatic amines discussed elsewhere (aniline, diphenyamine) - powdered carbon treatment of contaminated water might be attempted.

Ammonia
Very soluble in water - possibly dilute acetic acid for treatment - dilution.

Ammonium acetate
Dilution only feasible response.

Ammonium chloride
Dilution only feasible response.

Ammonia Compounds (Ammonium Compounds)
Dilution only practical treatment.

Ammonium Nitrate
1 g dissolves in 0.5 ml water at 20°C - dilution may be only practical treatment method.

Ammonium Perchlorate
Freely soluble in water - would slowly go over to ammonium chloride in contact with reducing materials such as organics on stream bottom - dilution only possible treatment.

Ammonium sulfate
Add $Ca(OH)_2$ to raise pH and remove NH_3 from water and ppt $CaSO_4$ - dilute.

Amyl Alcohol, commercial (isoamyl alcohol, isopentyl alcohol)
Slightly soluble in water - density = 0.83 - floats - Skimming required and possibly powdered carbon treatment.

Aniline (phenylamine, aminobenzene)
1 g dissolves in 28.6 ml water - reacts with acids and alkalies to form water-soluble salts. Removal might be accomplished by treatment of water with powdered carbon.

Antimony Compounds
Add $NaHCO_3$ or $Ca(OH)_2$ to precipitate antimony as an insoluble basic salt - recover precipitate.

Arsenic Compounds
Scavenge with alum floc to tie up arsenic in insoluble form - recover floc if possible.

Barium Carbonate
Almost insoluble in water - add Na_2SO_4 to precipitate less soluble $BaSO_4$.

Benzaldehyde (Benzoic aldehyde)
Soluble in 350 parts of water - very soluble in oils and gasoline - density = 1.04 - barely sinks in seawater - oxidizes in air to benozic acid - oil skimming if in contact with oil - powdered carbon treatment for water soluble fraction might be possible.

Benzene (Benzol, cyclohexatriene)
One part soluble in 1430 parts water - Miscible in oil - density = 0.88 - skimming necessary to remove.

Benzoic Acid (Benzenecarboxylic acid, phenylformic acid)
Solubility = 2.9 g/l at 25°C - add $NaHCO_3$ to produce sodium benzoate - human tolerance for this is up to 50 g/day.

Benzoyl peroxide (Lucidol)
Sparingly soluble in water - recover solid from bottom - use powdered carbon to remove water soluble portion if possible.

Boric Acid (H_3BO_3)
pH = 5.1 at 0.1 M - precipitate less soluble calcium borate with addition of $Ca(OH)_2$ - dilute - recover precipitate.

Bromine
One ml dissolves in thirty mls water - very heavy liquid - density = 3.1 at 20°C sinks to bottom - bottom recovery required - powdered carbon treatment for water soluble fraction if feasible.

n-butyl acetate (Butyl ethanoate)
Soluble in 120 parts water at 25°C - density = 0.88 - much of the spill will remain floating so skimming probably necessary - powdered carbon removal of water soluble fraction if possible.

Normal & Isobutyl Alcohol (butyl alcohol; 2-methyl-1-propanol)
Both fairly soluble in water - powdered carbon treatment might be attempted - also dilution.

Butyl Amines (n, sec, tert - Butylamine)
Miscible with water - ammonia odor - powdered carbon treatment of contaminated water if feasible.

Butyric acid (ethylacetic acid, butanoic acid)
Miscible with water - neutralize with $Ca(OH)_2$ - possibly try adsorption of butyrate on powdered carbon - dilute.

Calcium Carbide
Evolves acetylene in water leaving $Ca(OH)_2$ - treat with Na_2CO_3 if desirable to precipitate $CaCO_3$ and lower pH.

Calcium Chloride
Freely soluble in water with liberation of heat - add Na_2CO_3 to precipitate $CaCO_3$.

2,4,5-T acid esters and salts (esters and salts of 2,4,5-trichlorophenoxyacetic acid)
Esters nearly water insoluble - sodium salt water soluble - powered carbon treatment may be feasible for soluble fraction.

Calcium hypochlorite
Very water soluble - decomposes much more readily than sodium hypochlorite - little can be done except dilution.

Calcium phosphate, Dibasic ($CaHPO_4$)
Slightly soluble in water - $Ca(OH)_2$ can be added to make even less soluble by the common ion effect.

Carbon disulfide (carbon bisulfide)
Slightly water soluble - <0.005% - miscible in oils and gasoline-oil skimming if in contact with oil - powdered carbon treatment of contaminated water for soluble fraction - density = 1.25, therefore it sinks in water - use heavy liquid recovery system.

Carbon tetrachloride (Tetrachloromethane, perchloromethane)
1 ml dissolves in two liters of water - density = 1.59, therefore most would sink to bottom of water body - bottom recovery methods would be in order.

Chlorinated Isocyanurates
Soluble in water - add $Ca(OH)_2$ to suppress formation of hypochlorous acid - Powdered carbon treatment might be attempted.

Chlorine
0.7 wt% soluble in 20°C water (2.3 volumes of Cl_2 at STP). Powdered carbon treatment may be worth a try but probably

will not be very successful - soluble in basic solutions but not much help to the fish - large fish kills probable.

Chloroform (Trichloromethane)
One part soluble in 200 parts water at 25°C - density = 1.48 - sinks in water - insoluble fraction will have to be recovered from bottom - carbon treatment for soluble fraction may be possible.

Chloromethane (methyl chloride)
Slightly soluble in water - evaporates quickly producing a temperature of -23°C to -50°C. Powdered carbon treatment may be in order to remove water soluble fraction - density at 24°C = 1.0.

Chlorosulfonic Acid (Sulfuric chlorohydrin)
Very corrosive - explosive decomposition - Treatment of contaminated water with calcium hydroxide or sodium bicarbonate.

Chromic Acid (Chromium trioxide)
Neutralize with $NaHCO_3$ to produce chromic carbonate which is practically water insoluble.

Citric acid
64 wt% citric acid solubility at 30°C - citrate solubility can be reduced to one part in 1050 parts water by addition of $Ca(OH)_2$ with formation of calcium citrate.

Copper sulfate
Use potassium ferrocyanide to precipitate a reddish copper ferrocyanide which is very insoluble - ferrocyanides are of a very low toxicity order - they can pass through the stomach without breakup into HCN.

Cresols (Cresylic acid, cresylol, tricresol)
Similar action to phenol - powdered activated carbon treatment of contaminated water if possible.

Cyclic Herbicides, Misc.
Many are only slightly water soluble - float on water - skimming may be necessary - powdered carbon treatment to remove water soluble remainder may be attempted.

Cyclic Insecticides, Misc.
Treat contaminated water with powdered activated carbon, if possible.

Cyclic Insecticides and Rodenticides
Activated charcoal treatment if practical, of water in spill - otherwise dilution to <20 mg/l for strychnine, same order of magnitude for rotenone, which also rapidly decomposes in heat and light.

Cyclohexanol (Hexalin, hexahydrophenol)
3.6 wt% soluble in water at 20°C - heavy solid - may have to recover solid from bottom - adsorption of contamination on powdered carbon may be possible.

Cyclohexanone (Ketohexamethylene)
Solubility in water - 50 g/l at 30°C - density = 0.94 at 25°C - may have to skim after spill - if feasible use powdered carbon for removal of soluble portion.

Cyclohexylamine (Hexahydroaniline, aminocyclohexane)
Miscible with water - powdered carbon removal with pickup of the used carbon.

DDT (dichlorodiphenyltrichloroethane)
Practically insoluble in water - if wettable, will have to be recovered by desedimentation techniques possibly using alum floc and a polyelectrolyte - powdered carbon could be added, also, to insure soluble DDT uptake and removal.

1,2-Dibromo 3-chloropropane (DBCP, Fumazone, Nemagon)
Slightly soluble in water - density = 2.1 at 14°C sinks to bottom - must be recovered from bottom - possibly powdered carbon treatment of dissolved material.

Dibutyl phthalate (**n-Butyl phthalate**)
One part soluble in 2500 parts of water - density = 1.05 - sinks in water - insoluble fraction recovered from bottom - possibly carbon treatment for soluble fraction.

Dichlorobenzenes (m-, o-, and p-Dichlorobenzene)
Heavy liquids - density averages 1.3 - practically water insoluble - sinks to bottom - bottom recovery necessary with powdered carbon treatment of contaminated water if feasible.

2,4-D Acid (**2,4-dichlorophenoxyacetic acid**, Hedonal)
Almost water insoluble - soluble in oil - oil skimming required if oil contacted - otherwise powdered carbon treatment for water soluble fraction.

2,4-D Esters and Salts (2,4-dichlorophenoxyacetic acid esters and salts)
Salt solubility in water = 3.5% - ester is a heavy liquid soluble in oil - oil skimming in order - possibly powdered carbon treatment for water soluble fraction.

Diethylamine
Miscible with water - strongly alkaline light liquid - neutralize with dilute acetic acid - adsorb on powdered carbon if possible.

Diethanolamine (2,2-Iminodiethanol, diethyloamine)
Sold as a liquid - miscible with water - lower pH with dilute acetic acid - adsorb water soluble fraction on powdered carbon if possible.

Diethylene glycol (2,2'-Oxydiethanol, diglycol)
Miscible with water - water-glycol mixtures sink, though - powdered carbon treatment with collection of solid sludge.

Ethanolamine (Monoethanolamine)
Miscible with water - strongly basic - treat water with dilute acetic acid and adsorb on powdered carbon if possible.

Ethers, total
Slightly soluble in water - very soluble in oils - oil skimming called for if oil contacted. Powdered carbon treatment may be tried for water soluble fraction.

Esters of Monohydric Alcohols
Mostly water soluble - heavy liquids - fatty acid enters water insoluble - bottom recovery required - powdered carbon treatment necessary for water soluble esters.

Ethanolamines (mono, di, and triethanolamines)
Miscible with water - strong base - neutralize with dilute acetic acid - treat with powdered carbon if feasible.

Ethyl Acetate
One ml dissolves in ten ml water at 25°C - density = 0.90 - floats slowly decomposed by water acquiring an acid reaction - rapid skimming followed by powdered carbon treatment if possible.

Ethyl Acrylate (Acrylic acid ethyl ester)
Fairly soluble in water - easily polymerizes on standing to a non-toxic transparent substance - heat, light and peroxides (H_2O_2) speed up polymerization - density = 0.94 - floats on water - skimming to remove bulk - possibly powdered carbon treatment for water soluble fraction.

Ethyl Alcohol (Ethanol, alcohol)
Dilution only practical treatment for contaminated water.

Ethylamine (Monoethylamine, aminoethane)
Strong alkaline reaction - miscible in water - powdered carbon treatment may be possible - allow to remain alkaline to avoid splitting off CN gas.

Ethylbenzene
Density = 0.87 at 25°C - practically insoluble in water - floats on water surface - skimming, with powdered carbon treatment for water soluble fraction might be attempted.

Ethylene (Ethene)
One volume of gas dissolves in nine vol of water at 25°C - powdered carbon treatment of contaminated water might be attempted - otherwise dilution.

Ethylenediamine (1,2-Diaminoethane)
Freely soluble in water - strongly alkaline in reaction - add dilute acetic acid to form diacetate - powdered carbon treatment for removal if feasible.

Ethylene Glycol (1,2-Ethanediol)
Miscible with water - probably even glycol - water mixtures (density at 50/50 mixture = 1.08) are dense enough to sink to bottom - solids removed from bottom and possibly powdered carbon treatment.

Ethylene Oxide (Oxirane, Anprolene)
Soluble in water - powdered carbon treatment for contaminated water.

Ethylenimine (Ethylene imine, Aziridine, dimethylenimine)
Miscible with water - polymerizes easily - strongly alkaline - add dilute acetic acid to neutralize - adsorb on powdered carbon if possible.

Ethyl Ethers, all
Water contains 6 wt% ether at 25°C - most of the ether would float, but too dangerous (fire hazard) to skim - possibly treat with powdered carbon for soluble ether.

Ethyl Formate
One part soluble in ten parts water with gradual decomposition into formic acid and ethanol - density at 20°C = 0.92 - floats - rapid skimming with powdered carbon treatment if possible.

2-Ethylhexylacrylate (Octyl acrylate)
Liquid very slightly soluble in water - density = 0.89 at 20°C - floats - rapid skimming followed by powdered carbon treatment if possible.

Fatty Acids (Stearic, oleic, linoleic acids)
Very slightly water soluble - most float on water - soluble in oils and gasoline - oil skimming for removal.

Ferbam (dimethyldithiocarbamic acid, Carbamate)
Solubility in water = 120 ppm - recover solid from bottom - use powdered carbon to remove water soluble fraction if possible.

Ferrous sulfate
Water soluble - precipitate as a hydroxide by $NaHCO_3$, buffering.

Fluorine, hydrofluoric acid
Add $Ca(OH)_2$ to contaminated water to precipitate harmless CaF_2.

Formaldehyde Solution (Formalin, Formol)
Very water soluble - ammonium acetate transforms formaldehyde to much less toxic methenamine - add ammonium salts if practical - powdered carbon treatment also could be effective.

Formic Acid
Liquid miscible with water - caustic to skin - neutralize with $Ca(OH)_2$ - possibly try adsorption of formate on powdered carbon - dilute.

Fumaric acid (trans - Butenedioic acid)
0.63 g soluble in 100 ml water at 25°C - recover solid from bottom - possibly adsorb dissolved material on powdered carbon.

Fungicides, Acyclic
Not very water soluble - powdered carbon treatment is a possibility.

Fungicides, Misc.
Most are not very water soluble - adsorption on powdered carbon only possibility.

Fungicides, total cyclic
Most nearly water insoluble - powdered carbon treatment only practical removal method.

Furfural (2-Furaldehyde)
One part soluble in eleven parts water - density = 1.16 - sinks in water - carbon treatment with recovery of carbon for soluble fraction.

Furfuryl Alcohol (2-Furylcarbinol, 2-Furancarbinol)
Miscible with water, but unstable in water - easily resinified by acids - add dilute acetic acid to speed up resinification - powdered carbon treatment may be possible.

Glycerine, syn. & nat. (Glycerol)
Heavy liquid miscible with water - probably water and glycerol mixtures all sink to bottom - powdered carbon treatment for removal may be possible - dilution.

Glyoxal (Ethanedial, oxalaldehyde, biformyl)
Solid polymerizes quickly on contact with water with violent reaction - sold as solid or as 40% aq. soln. containing polym. inhibitors - powder carbon treatment for aqueous solution may be possible.

Halogenated Hydrocarbons
Most practically water insoluble - quite soluble in oil and gasoline - skimming equipment use in order if oil slicks are present - powdered carbon treatment to remove water soluble fraction may be attempted.

Herbicides and Plant Hormones
Treatment of contaminated water with powder carbon with precipitation of sludge or filtration - acute human toxicity - little can be done about water soluble fraction except perhaps powdered carbon treatment.

Herbicides and Plant Hormones, acyclic
Variable water solubilities - usually slightly soluble -

there are 14 gibberellins (plant hormones) for example - all are slightly soluble solids. Most herbicides more water soluble - powdered carbon treatment for water soluble fraction if feasible - recovery of solids from bottom of water body.

1,6-Hexanediamine (Hexamethylenediamine)
Freely water soluble - powdered carbon treatment of contaminated water might be attempted.

1-Hexanol (n-hexyl alcohol)
Slightly soluble in water - density = 0.81 at 35°C - floats on water - skimming probably required - adsorption on powdered charcoal for dissolved material if possible.

Hydrochloric Acid (Muriatic acid)
Neutralize with sodium bicarbonate, dilute.

Hydrocyanic Acid (Hydrogen Cyanide)
Add $Ca(OH)_2$ to suppress formation of HCN gas or chlorinate or attempt precipitation with Fe^{+3} - little else can be done besides dilution.

Hydrogen Peroxide
Make water alkaline with $NaHCO_3$ to speed decomposition of peroxide - dilute.

Hypochlorites
Addition of $NaHCO_3$ will speed Cl_2 evolution and hypochlorite breakdown, but fish will still suffer toxic effects.

Lactic Acid (D-lactic acid, DL-lactic acid, L-lactic acid)
Soluble in water - possibly powdered carbon treatment - dilution.

Lead Arsenate
Use alum floc to remove arsenate by adsorption - add $Ca(OH)_2$ to precipitate insoluble basic lead carbonate - recover precipitates.

Lead - Compounds
Very difficult to recover - perhaps dithizone or EDTA followed by adsorption of the lead complex with powdered carbon treatment.

Lindane (HCH; 1,2,3,4,5,6 - hexachlorocyclohexane)
Insoluble in water - white powder - has to be removed as a

sediment, if suspended in water - alum and polyelectrolyte treatment might be attempted.

Isooctyl Alcohol (a mixture of isomeric, branched-chain primary alcohols)
Only very slightly soluble for most part - density = 0.8 - floats on water - skimming required for recovery - powdered carbon treatment for water soluble fraction if possible.

Isoprene (2 - Methyl - 1,3 - butadiene)
Liquid practically insoluble in water - density = 0.68 - floats on water - remove floating isoprene with oil spill equipment - possibly treat contaminated water with powdered activated carbon.

Isopropyl Acetate
One part soluble in 23 parts water at 27°C - liquid density = 0.87 at 20°C - floats - rapid skimming followed by powdered carbon treatment if possible.

Isopropylacetone (Methyl Isobutyl Ketone, hexone)
Liquid moderately soluble in water (1.91 wt%) - density = 0.80 at 20°C - rapid skimming and powdered carbon treatment if possible.

Isopropyl Alcohol (Isopropanol, 2 - propanol)
Miscible with water - can be salted out of aqueous mixtures but too much salt is required to do this - not very feasible - powdered carbon treatment and dilution is probably only practical treatment.

Isopropylamine (2 - aminopropane)
Miscible with water - strong base - neutralize with dilute acetic acid - remove with powdered carbon adsorption if possible.

Isopropyl ether (diisopropylether)
Slightly soluble in water (0.2 wt% at 20°C - density = 0.73 at 20°C-floats - rapid skimming, if not too hazardous, followed by powdered carbon treatment if possible.

Magnesium Compounds
Ppt. $Mg(OH)_2$ with $Ca(OH)_2$ - remove excess Ca with soda softening (Na_2CO_3).

Magnesium Sulfate
Magnesium can be precipitated as $Mg(OH)_2$ by $Ca(OH)_2$ - calcium sulfate can be reduced by soda softening if desired.

Maleic Anhydride (cis-Butendioic anhydride, Toxilic anhydride)
Solid briquettes - water soluble - possible bottom recovery if fast enough - powdered carbon treatment for remainder if feasible.

Methyl Acetate
Soluble in water - liquid density = 0.93 - possibly powdered carbon treatment for removal - perhaps skimming of floating material.

Methyl Alcohol (Methanol, carbinol, wood alcohol)
Ethanol inhibits the metabolic oxidation of methanol - perhaps some ethanol and bicarbonate might be added to methanol spill if there is immediate danger of ingestion - otherwise dilution is the only practical means of spill dissipation.

Methylamines
One volume of water dissolves 959 volumes of gas - a stronger base than ammonia - perhaps powdered carbon treatment would be effective.

Methyl Ethyl Ketone (Ethyl Methyl Ketone, 2-Butanone)
1 pt. soluble in 4 pts. water - powdered carbon treatment for spills is a possibility.

Methyl Methacrylate (Methacrylic acid)
Very slightly soluble in water - density - 0.94 at 20°C - Oil skimming required, powdered carbon treatment of water soluble fraction, if possible.

Methyl parathion (0,0-Dimethyl 0-p-nitrophyl phosphorothioate)
50 ppm water solubility of crystals - density = 1.36 at 20°C sinks to bottom - bottom recovery necessary with powdered carbon treatment for water soluble fraction if feasible.

Mercury Compounds
BAL (Dimercaprol), a water soluble mercaptan, is recommended as a chelating agent for mercury - however, this is not of much value if the Hg is still in solution - add Na_2CO_3 to bring down insoluble carbonate - recover carbonate from bottom.

Mercury Fungicides
Usually metallo-organics that can be removed by powdered carbon if such treatment is feasible.

Monohydric Alcohols, unsubstituted
Powdered carbon treatment for water soluble alcohols might be attempted - alcohols through butanol are infinitely soluble in water - become less soluble through nonanol - water insoluble and solid after decanol - the infinitely soluble alcohols can be made to separate from aqueous solution by addition of potassium carbonate - water then would require skimming to remove alcohol and treatment of water for contained K_2CO_3.

Morpholine (Tetrahydro-2H-1,4-oxayine)
Liquid miscible in water - strong, corrosive base - neutralize with dilute acetic acid - adsorb on powdered carbon if possible.

Nabam (Dithane D-14)
Moderately soluble in water - probably must rely on powdered carbon treatment due to relatively high solubility.

Naphthalene
Powdered carbon treatment may be possible.

Nickel Compounds
Mostly water soluble - Nickel forms a water insoluble complex with dimethylglyoxime (pinkish red) that is used in cosmetics, hence probably not toxic - as a stopgap, add dimethylglyoxime dissolved in Ethanol to nickel spill - remove nickel complex by use of alum and powdered carbon and polyelectrolyte.

Nickel Sulfate
One part soluble in 1.4 parts water - add $Ca(OH)_2$ to form insoluble $Ni(OH)_2H_2O$ - recover ppt. if desired.

Nitric Acid
Lower pH of contaminated water with $NaHCO_3$ or $Ca(OH)_2$ - dilute resulting nitrates.

m-Nitroaniline (m-Nitraniline)
One gram dissolves in 880 ml of water - density of solid = 0.90 - floats on water - recovery by skimming equipment - caustic in reaction, but since the salt is much more soluble than the base it probably should not be neutralized - adsorb dissolved material on powdered carbon if feasible.

Nitrobenzene (Nitrobenzol)
Density = 1.21, therefore it sinks in water - one part soluble in 500 parts water - freely soluble in oils and gasoline - oil skimming would be in order if oils are contacted - bottom recovery equipment needed if spilled into water body - powdered carbon treatment might be attempted for soluble fraction.

Nitrophenols (o - and p - nitrophenol)
Para most toxic - moderately water soluble - adsorption on powdered carbon is the only possibility.

Nitrous Oxide (laughing gas, dinitrogen monoxide)
At 20°C and 1 atmos., 1ℓ of gas dissolves in 1.5ℓ of water - No HNO_3 formed - no treatment required.

Nonyl Phenol (Mixture of Monoakyl phenols)
Practically water insoluble - density = 0.95 - floats on water and therefore can be removed with oil spill equipment - contaminated water may be treated with powdered activated carbon.

Oxalic Acid
Add $Ca(OH)_2$ to precipitate as relatively unsoluble calcium oxalate - recover precipitate if possible - recover solid oxalic acid.

Parathion (Niran, DNTP, DPP, E-605, Thiophos 3422)
20 ppm soluble in water - heavy liquid - density = 1.26 at 25°C - sinks to bottom - bottom recovery necessary - powdered carbon treatment to remove water soluble parathion if possible.

Pentachlorophenol (Penta)
A solid - density = 1.978 - sinks in water - almost water insoluble - bottom recovery necessary - carbon treatment for water soluble fraction, if feasible.

Pentane (n-pentane)
360 ppm soluble in water at 16°C - density = 0.61 at 30°C - floats on top of water - skimming required powdered carbon adsorption for dissolved material may be possible.

Perchloric Acid
Treatment of contaminated waters by addition of lime or $NaHCO_3$ (calcium hydroxide) - otherwise dilution.

Pesticides, Insecticides, Acyclic
Powdered carbon treatment of contaminated water for water soluble fraction, if feasible - oil skimming if in contact with oil.

Phenol (carbolic, phenic, phenyl hydroxide, hydroxybenzene)
Solid - 1g dissolves in 15 ml water - if spill area is

reasonably small in size, and can be contained, powdered charcoal treatment becomes possible - precipitate with a coagulant - physical sludge removal. If spill is in a large water volume, dilution may be the only treatment - any amount dangerous - pH of aqueous solutions =6, forms water soluble salts with bases.

Phenylmercuric Acetate (Acetoxyphenylmercury, PMA)
1 part soluble in 600 parts water - solid - powdered carbon only possible treatment.

Phosphoric Acid
Lime, $Ca(OH)_2$, to neutralize and precipitate calcium phosphate.

Phosphorus
Three forms; white, black and red.
White - Very insoluble in water - ignites at 30°C - cover with water! - retrieve physically from underwater - fairly soluble in oil and gasoline - oil skimming if in contact with oil - other two forms are less soluble in organics and can be physically retrieved without combustion.

Phosphorus Oxychloride (phosphoryl chloride)
Soluble in water with decomposition and heat to chlorine and phosphoric acid - add $NaHCO_3$ to neutralize phosphoric acid produced.

Phosphorus Pentasulfide (phosphoric sulfide, phosphorus persulfide)
H_2S generation - suppress with addition of $Ca(OH)_2$ or $NaHCO_3$ to contaminated water.

Phosphorus Trichloride
Soluble in water with liberation of much heat - heavy (density = 1.57), clear liquid - decomposes in water to phosphoric acid and $C\ell_2$ - add $Ca(OH)_2$ to precipitate and neutralize H_3PO_4.

Phthalic Anhydride
Solid - one part soluble in 162 parts water - density = 1.53 - recovery from bottom required along with powdered carbon treatment for water soluble fraction if feasible.

Polyhydric Alcohols and Esters (polyhydroxy alcohols and esters)
Some solid - some liquids - freely soluble in water - adsorption on powdered carbon is a possibility.

Potassium Compounds
For the hydroxide, add acetic acid to neutralize - otherwise dilute.

Potassium Hydroxide
Treatment with dilute acetic acid to lower pH - dilution of potassium acetate.

Potassium Iodide
Solubility = 1.4 g/mℓ water - very slowly oxidizes to give elemental iodine - dilution only practical treatment.

Potassium Pyrophosphate
Add $Ca(OH)_2$ to precipitate insoluble $Ca(PO_4)_2$.

Potassium Sulfate
Dilution best treatment practical for a water spill.

Propionic Acid (Methylacetic acid, propanoic acid)
Oily liquid - density = 0.98 at 30°C - barely floats - miscible with water - can be salted out of water solutions by $CaCℓ_2$ or other salts (probably not very soluble in seawater) rapid skimming along with powdered carbon treatment may be feasible.

Propyl Acetate (acetic acid n-propyl ester)
1.6 g/100 mℓ water, solubility at 16°C - density = 0.88 at 20°C - floats on water - skimming probably required - possibly powdered carbon treatment for soluble fraction.

n-Propyl Alcohol (propylic alcohol, 1-propanol)
Miscible in water - Powdered carbon only possible treatment.

Propylamines
Usually miscible with water - alkaline - neutralize with dilute acetic acid - adsorb on powdered carbon if possible.

Propylene (propene)
Gas - shipped as liquid in cylinders at 136 psi - very slightly soluble in water - powdered carbon treatment for removal from water may be feasible.

Propylene Dichloride (1,2 - Dichlorophophane)
Liquid slighly soluble in water - density = 1.16 - therefore sinks in water - bottom recovery necessary along with powdered carbon treatment of soluble fraction if feasible.

Propylene Glycol
Miscible with water - liquid with about same density as seawater - possibly powdered carbon treatment for removal - dilution.

Propylene Oxide (Propene Oxide)
One part soluble in 100 parts water - density = 0.86 -

floats - skimming is in order along with powdered carbon treatment for removal of dissolved fraction if possible.

Pyridine
Density = 0.97, miscible in water - soluble in oil and gas - oil skimming where there is oil contact - powdered carbon treatment of contaminated water, if feasible.

Silver Cyanide
Insoluble in water - add $NaHCO_3$ to stabilize and recover from bottom - Chlorinate.

Silver Nitrate
Add NaCl to precipitate AgCl - recover AgCl precipitate.

Sodium Acetate
Dilution only practical treatment.

Sodium Borate
Precipitate much less soluble calcium borate by addition of $Ca(OH)_2$ - remove precipitate from bottom.

Sodium Carbonate
Usually too high in pH to leave untreated - neutralize with dilute acetic acid.

Sodium Chlorate
Very water soluble - neutral pH in solution - dilution is only practical treatment.

Sodium Chromate
Add Fe^{+3} and $NaHCO_3$ to precipitate Ferric chromate.

Sodium Compounds
Dilution is only practical treatment for most - caustic can be treated with dilute acetic acid.

Sodium Fluoride
Add $Ca(OH)_2$ to precipitate insoluble CaF_2.

Sodium Hydrosulfite
Very soluble in water - oxidizes to bisulfite then to bisulfate - acidic - add $NaHCO_3$ to neutralize acidity - dilute.

Sodium Hydroxide
Add dilute acetic acid to neutralize.

Sodium Metal
Strong caustic former - add dilute acetic acid to lower pH.

Sodium Methylate (Sodium methoxide)
Solid Decomposes in water to NaOH and CH_4 - add dilute acetic acid to neutralize - dilute.

Sodium Phosphates (monobasic, dibasic and tribasic)
$Ca(OH)_2$ precipitates all sodium orthophosphates - metaphosphates not well precipitated unless 4/1 excess lime to phosphate weight ratio is added - precipitates quite insoluble.

Sodium Silicate
Acidify and flocculate with dilute acetic acid.

Sodium Sulfate
Best to allow dissipation of this by dilution when spilled in water.

Sodium Sulfide (sodium monosulfide)
Addition of $NaHCO_3$ or $Ca(OH)_2$ to suppress formation of H_2S.

Sodium Sulfite
Oxidizes in air to sulfate - dilution only practical removal method - oxidation of large water body impractical.

Sorbitol (d-Sorbitol, Sorbol, d-Sorbite, hexahydric alcohol)
Freely soluble in water - heavy liquid - pH = 6-7 - probably sorbitol-water mixtures sink to bottom - powdered carbon treatment for removal may be possible.

Sulfur Dioxide
Forms sulfurous acid in water (H_2SO_3) - add $NaHCO_3$ to speed up process of SO_2 emission.

Sulfuric Acid (Oil of vitriol)
Treatment of contaminated water with $NaHCO_3$ or $Ca(OH)_2$.

Tertiary Butyl Hydroperoxide
Slightly soluble in water - density = 0.9 at 20°C - floats as liquid on water - skimming necessary in case of spill - powdered carbon treatment of dissolved fraction if possible.

Tetraethylene Glycol
Heavy liquid miscible with water - powdered carbon treatment may be effective.

Tetraethyl Lead (Lead tetraethyl)
Acute human toxicity - nearly insoluble in water - density = 1.65 - sinks to bottom of water - very difficult to recover - perhaps complexing with calcium salt of EDTA and dimercaprol (BAL) might be used as a stopgap measure.

Tetralin (1,2,3,4-Tetrahydronaphthalene)
Insoluble in water - density = 0.96 at 25°C - floats - Skimming required.

Tetramethyl Lead (Lead tetramethyl)
Soluble in oil - insoluble in water - oil skimming if contacted by gasoline or oils - possibly powdered carbon treatment for soluble fraction - possible lead complexing with Ca EDTA salt - density = 1.99 - sinks in water - both recovery methods.

Toluene (Toluol, methylbenzene, phenylmethane)
Very slightly soluble in water - density = 0.87 at 20°C floats on top - use skimming to remove - powdered carbon could be added to remove small water soluble amount.

Trichloroethane (Vinyl Trichloride)
Heavy liquid - density = 1.46 at 20°C - practically water insoluble - bottom recovery equipment needed in case of spill into water body.

Trichloroethylene (Trichloroethene, ethinyl trichloride)
Heavy liquid (density - 1.46 at 20°C) - practically insoluble in water - sinks to bottom - must be recovered from the bottom - slowly decomposes in light to form HCl.

2,4,5-Trichlorophenol + Salts (Dowicide 25, Omal)
Weakly acidic - solium salt much more water soluble than the acid - powdered carbon treatment is the only possibility other than dilution.

2,4,5-T Acid (2,4,5-Trichlorophenoxyacetic Acid)
Acid nearly water insoluble - soluble in oils - solid has to be recovered from the bottom - oil skimming if in contact with oil - powdered carbon treatment for removal of water soluble fraction, if feasible.

Triethanolamine (2,2',2"-Nitrilotriethanol)
Miscible with water - strong base - neutralize with dilute acetic acid - remove salt on powdered carbon, if possible.

Triethylene Glycol
Miscible with water - heavy liquid - probably glycol - water mixtures sink to bottom - powdered carbon treatment, if possible - dilution.

Trimethylamine
Gas - soluble in water - sold as 25% H_2O solution or liquified gas - sorption on powdered carbon might be attempted.

Turpentine
Water insoluble - density = 0.86 - floats on water - could be retrieved by skimming.

Urea (carbamide)
One gram dissolves in one ml water - pH of 10% water solution = 7.2 - dilution is probably best removal method.

Vinyl Acetate
Water solubility 1/g/50 ml - density = 0.93 - floats - polymerizes in light to a solid mass - oil skimming and powdered carbon treatment may be effective.

Xylenes (Xylols)
Nearly insoluble to insoluble in water - density = 0.85-0.9 - floats on water - skimming called for - powdered carbon treatment may be attempted for any water soluble fraction - very soluble in oil and gasoline.

zinc Acetate
Add $Ca(OH)_2$ to precipitate insoluble $Zn(OH)_2$ - Remove precipitate.

Zinc Chloride
Add $NaHCO_3$ to precipitate the insoluble basic zinc carbonate - recover precipitate if possible.

Zinc Sulfate
Add $NaHCO_3$ to precipitate insoluble basic zinc oxide - Recover precipitate, if possible.

APPENDIX F

ENVIRONMENTAL FACTORS

Appendix F illustrates the usage of a general dispersion model for a soluble pollutant in two possible aquatic environments. This is followed by a summary of present knowledge concerning the chemical and biological interactions affecting DDT released to the aquatic environment. These examples should help illuminate the complexities involved with predicting the environmental fate of hazardous materials after a spill incident.

General Model for Dispersion of Soluble Pollutants

In a turbulent body of water there are two phenomena that will significantly affect the movement of a contaminant once it has been released: convection and eddy diffusion. Convection is the result of current velocity patterns in the water body, while eddy diffusion is dependent upon the natural turbulence of the water within the current structure. The two forces work in conjunction with convection currents transporting the contaminant plume and eddy currents enlarging the sphere of influence of the plume while reducing the concentration level of the plume interior.

Although there are no absolute boundaries defining the exact extent of the contaminant plume, individual concentration regimes can be followed. For the sake of this example, it is convenient to use the critical concentration of a contaminant as defined earlier in this report as the concentration regime of interest. Diachishin(2) has obtained a three dimensional solution to the classical mass conservation equation:

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} + V\frac{\partial C}{\partial y} + W\frac{\partial C}{\partial z} = Dx\frac{\partial^2 C}{\partial x^2} + Dy\frac{\partial^2 C}{\partial y^2} + Dz\frac{\partial^2 C}{\partial z^2} \qquad (1)$$

yielding:

$$C(x,y,z,t) = \frac{K}{t^{3/2}} \exp\left\{-\frac{1}{4}t\left[\frac{(x-ut)^2}{Dx} + \frac{(y-Vt)^2}{Dy} + \frac{(z-wt)^2}{Dz}\right]\right\} \qquad (2)$$

where C is the concentration of pollutant,
x,y,z refer to coordinates in a three dimensional box
u,v,w are velocities in the x,y,z directions, respectively,
Dx,Dy,Dz are diffusion coefficients,
t is time, and
K is a constant evaluated from boundary conditions.

Assuming that lateral and vertical velocities are negligible, the equation reduces to:

$$C(x,y,z,t) = \frac{K}{t^{3/2}} \exp\left\{-\frac{1}{4}t\left[\frac{(x-ut)^2}{Dx} + \frac{y^2}{Dy} + \frac{z^2}{Dz}\right]\right\} \qquad (3)$$

Using a specific critical concentration enables calculation of the boundary position at any time.

As an example, the diffusion pattern has been calculated for a spill of 1000 gallons of phenol at a point 300 meters offshore in both a moving and a stationary environment. The critical concentration level has been selected as 0.001 mg/l, the taste threshold of phenol.

Figure F-1 diagrams the position and size of the phenol spill at intervals of 6, 24 and 72 hours after the spill. A current of one knot and high eddy diffusivities have been assumed. Immediately after the spill the affected area begins to grow in size. This growth continues until there is no longer enough phenol to produce a concentration of 0.001 mg/l or more within the volume enclosed. At that time, the boundaries begin to recede. Meanwhile, the center of the spill continues to move downstream at the one knot velocity of the convection current. When the threshold boundaries recede to the center location, dilution is complete and the phenol can no longer be tasted even though it is present in minute quantities over a wide area.

Figure F-2 depicts a similar spill incident into a body of water with no convection currents and low eddy diffusivities. In this case, the initial point of the spill remains as the center of the diffusing area throughout the dilution process. Because of the lower diffusivities, the contaminated volume is still growing after 72 hours. However, the threshold boundary of 0.001 mg/l will eventually reach a maximum size and then begin to recede as in the preceding case. When this boundary approaches the center point, dilution is complete.

Although hypothetical, these examples serve to illustrate the general nature of natural dilution processes and the order of magnitude of the time frame necessary for dilution to reduce the concentration of a pollutant to innocuous levels.

Biological and Chemical Behavior of DDT

An example of the complicated route taken in the course of the environmental fate of one hazardous material, DDT, may serve to deepen appreciation of the nature of environmental interaction.

The behavior of most inorganic substances in natural waters will be ultimately dependent upon their elemental composition. Transformations of broad groups of the elements as well as important specific examples have been discussed. Although the discussion of carbon is generally applicable to organic materials entering surface waters, the important biological implications of carbonaceous compounds warrants their further consideration.

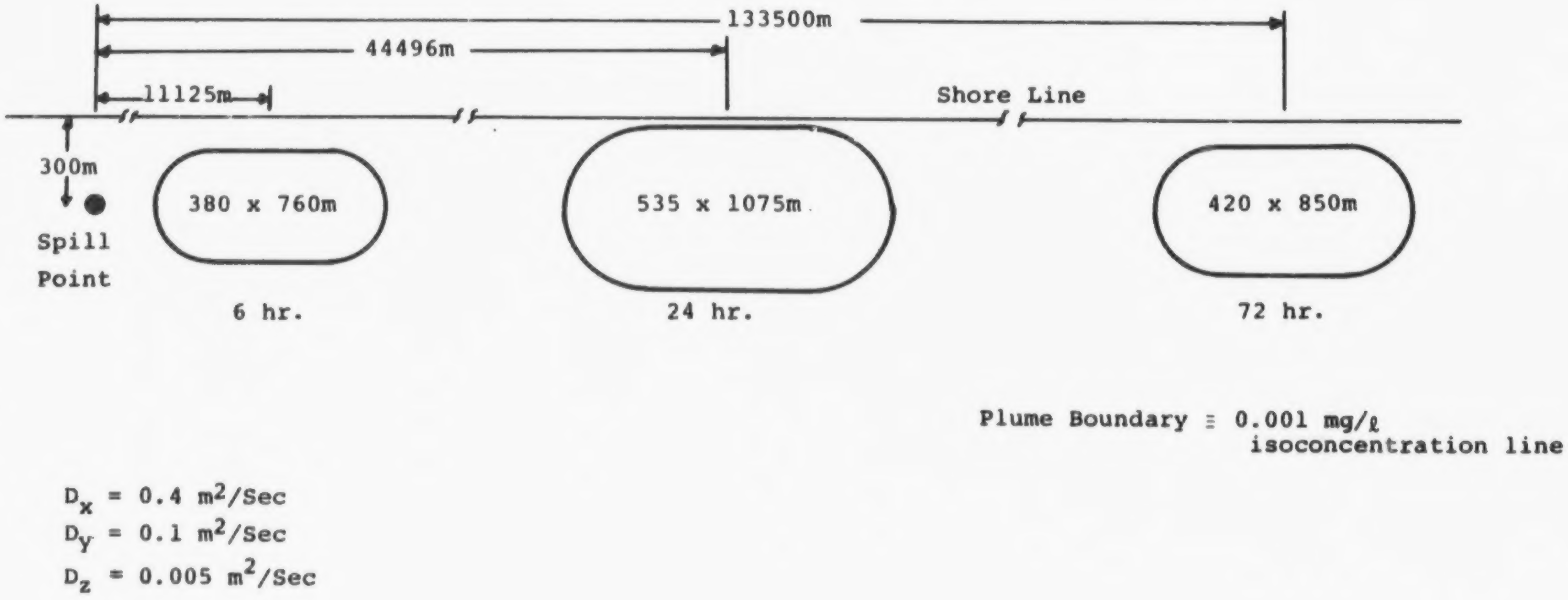


Figure F-1

Movement of a 1000 Gallon Phenol Spill - One Knot Current

FIGURE F-1. Movement of a 1000 Gallon Phenol Spill - One Knot Current

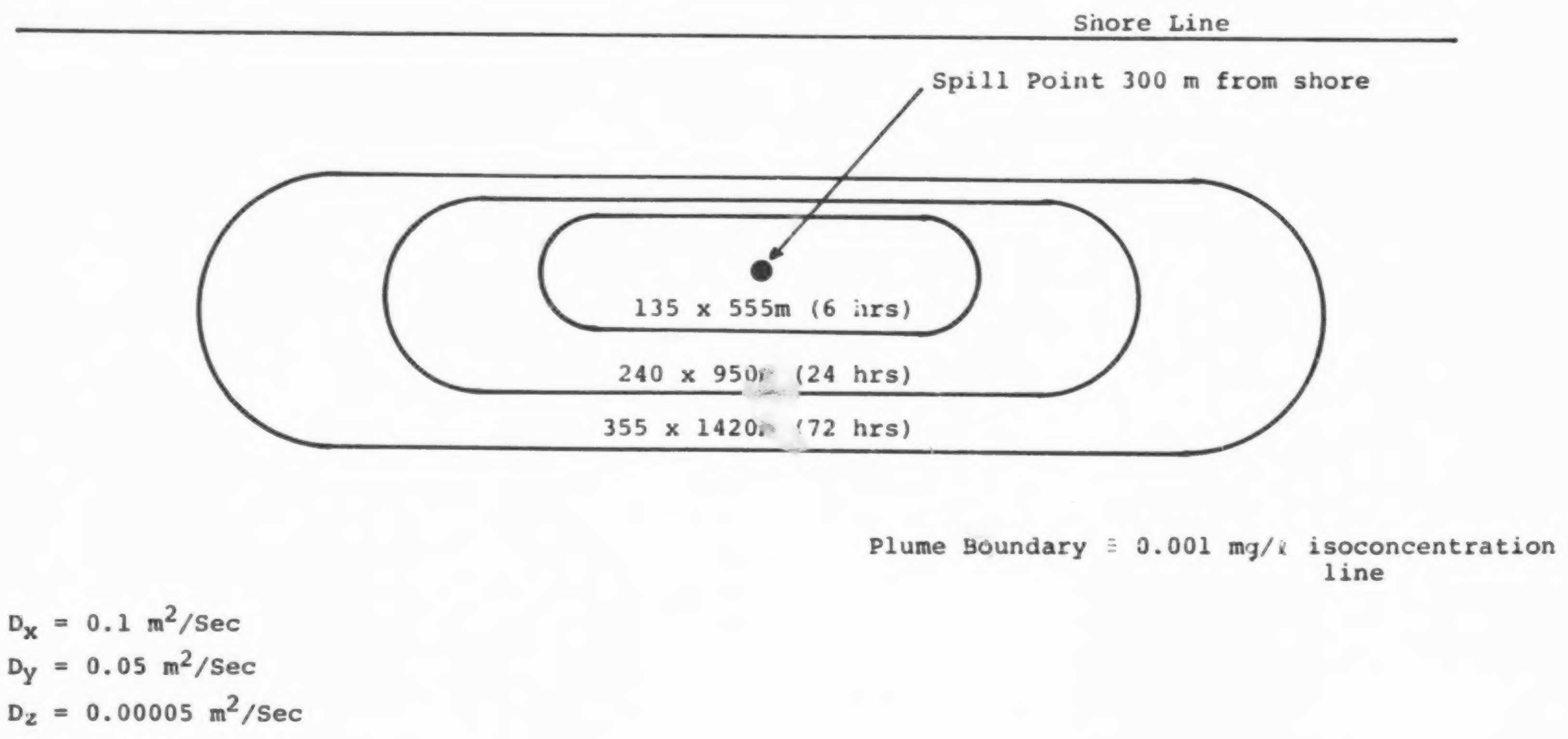


FIGURE F-2. Movement of a 1000 Gallon Phenol Spill - No Current

A general discussion of the fate of any compound in the environment must be qualified. Description of the "fate" of a given material must therefore consist of a series of assumptions based on pollutant behavioral measurements and quantitative data on the content of the compound in the various ecological compartments. The primary obstacle to efficient use of quantitative data on the extent of a given pollutant in any ecological compartment for predictive purposes is the lack of concomitant measurements of compartmental mass. Thus, present information is sufficient to establish background pollutant levels for several compound types in the major ecological compartments, but is insufficient to predict the distribution of the pollutant as a percentage of that applied to a given system. Of the potential environmental pollutants, DDT has been the most studied. A relative paucity of data exists for the environmental effects of other pollutants. DDT is useful for study because it has been in widespread use longer than any other pesticide, and it has a wide interaction with all the potential transport pathways for man-made chemicals in the environment. The general reactions of other organic chemical pollutants in the aquatic environment may be expected to be analogous to DDT. However, the degree to which this analogy is valid can only be inferred from a detailed knowledge of the properties of the individual chemicals.

Delivery of DDT to the point of use presents the potential of collisions, fires, derailments and other stresses which may release large quantities of the material into the environment. Approximately 80% of the DDT tonnage is carried by trucks and motor carriers, 17% by rail and 3% by water.(6) Furthermore, storage and actual use of the material for agriculture, forestry and municipal purposes provide further hazards for the entrance of excessive quantities of material into the environment.

The potential fate of DDT entering the aquatic environment follows that outlined in Figure 6. A model containing more detailed information with respect to DDT concentration mechanisms is outlined in Figure F-3. The values given indicate ranges of magnitude of DDT concentrations reported in environmental studies.(81) As much as 50% of the DDT entering water may be codistilled in 24 hours,(11) representing a significant exit route from the aquatic system which is highly affected by relatively small changes in temperature and DDT concentration.

The water solubility of DDT, as is the case with many of the chlorinated hydrocarbons, is quite low, not exceeding approximately 1 ppb. However, DDT is strongly sorbed to

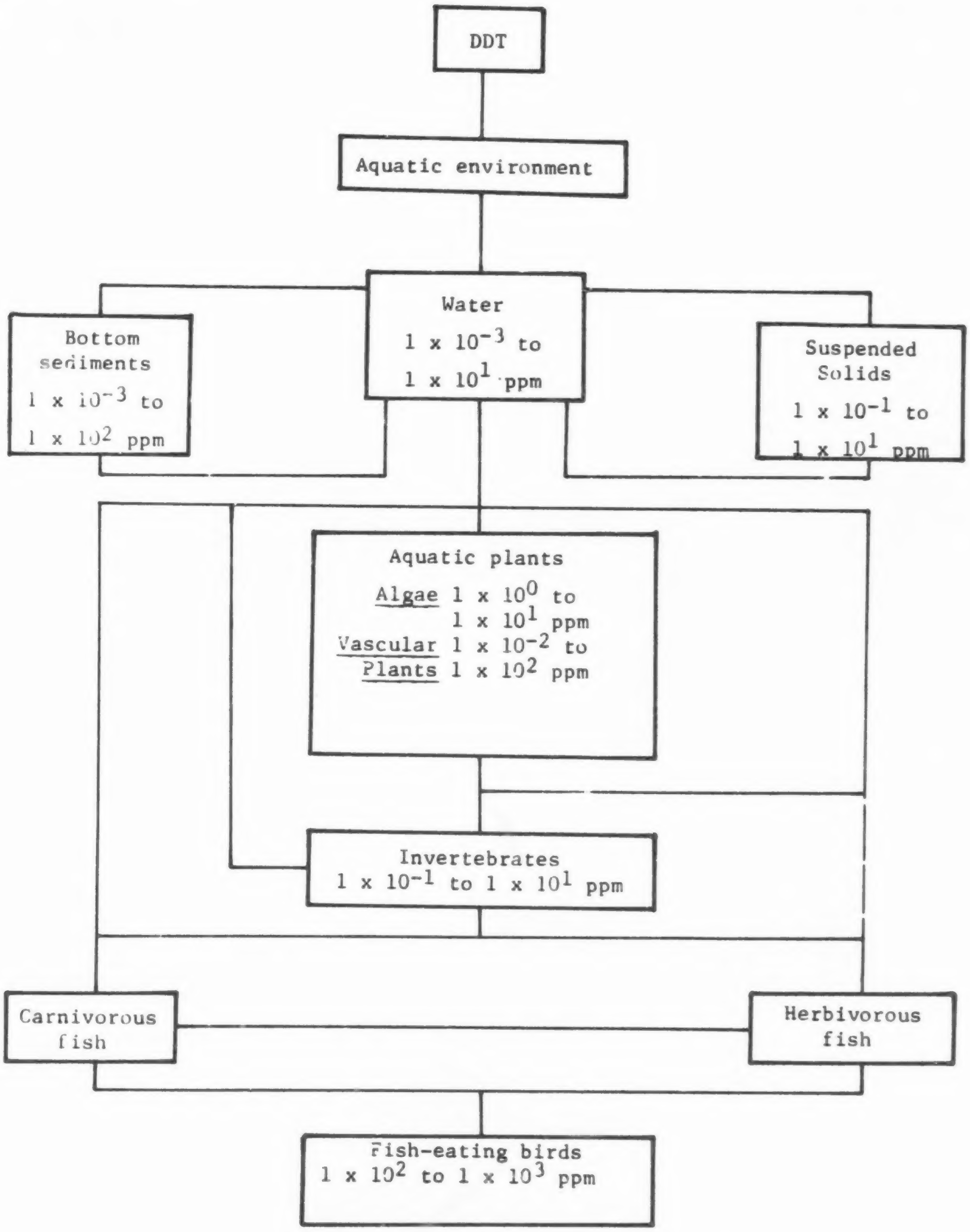


FIGURE F-3. Model of DDT in the Aquatic Ecosystem (Modified from Schneider)(81) suspended particulate matter; consequently, water samples analyzed for DDT without prior removal of suspended matter may exceed 10 ppm. Therefore, the particulate complex is likely the major transport vehicle for DDT in the aquatic environment. Thus, the nature and importance of sedimented and suspended particulate matter in governing the fate of pollutants in water is well illustrated.

The solubility of DDT and other chlorinated hydrocarbons in oils is extremely high with respect to their solubility in water. In fact, DDT is 8 x 10^7 times more soluble in oils than in water. The environmental consequences of this characteristic are significant. DDT can readily pass through the cell membrane of an organism where it will remain as the intact molecule until decomposed after the death of the organism or until it is consumed by another life form. Thus, DDT is accumulated in increasing quantities in the aquatic food chain. The model of DDT in the aquatic ecosystem is therefore essentially a model of the food chain.

Plants and invertebrates obtain DDT directly or indirectly from bottom sediments, suspended solids and water. Fish consuming the contaminated lower forms concentrate the DDT of a relatively large quantity of food organisms. Birds consuming fish may contain DDT in quantities as high as 1 x 10^3 ppm.

The affinity of DDT for hydrophobic surfaces results in its direct uptake by many organisms including fish, and therefore strict accumulation in the food chain represents only a "simplified" model of potential mechanisms for entrance of DDT into the higher chain.

APPENDIX G

PRESENT RESPONSE AND CONTINGENCY PLANS

In reviewing the available contingency plans from both the private and public sectors, plans of many different orientations and structures were received and summarized. Summaries of representative plans appear here preceeded by a listing of where the plans may be obtained in their entirety. The ChemTREC program is not presently operable, but parallels closely its predecessor, the E. I. DuPont de Nemours & Company TERP program.

The National Contingency Plan (June, 1970)
Federal Water Quality Administration
U. S. Department of Interior
Washington, D. C.

Ohio Basin Region Contingency Plan (Preliminary May, 1970)
Regional Operations Center
Room 7027, Federal Office Building
550 Main Street
Cincinnati, Ohio 45202

State of Maine Contingency Plan (January, 1970)
Portland Harbor Pollution Abatement Committee
40 Commercial Street
Portland, Maine 04111

The Kanawha Valley Industrial Emergency Planning Council Plan
from a paper presented by James B. Stone at the
Compressed Gas Association Annual Meeting, Waldorf-Astoria Hotel,
New York, New York (January 20, 1970)

James B. Stone
Union Carbide Corporation
Chemicals and Plastics
South Charleston, West Virginia

Waterwork Warning Network Plan Lower Mississippi River Engineering Division
(January 20, 1969)
Louisiana State Department of Health
325 Loyola Avenue
P. O. Box 60630
New Orleans, Louisiana 70160

Port of Los Angeles Oil Spill Contingency Plan (1970)
Lionel H. De Santy
Port Warden
Port of Los Angeles
255 W. Fifth Street
San Pedro, California

National Agricultural Chemicals Association
Pesticide Safety Team Network
1155 15th Street N. W.
Washington, D. C. 20005

TERP Program
E. I. Du Pont De Nemours & Company, Inc.
Traffic Department
Wilmington, Delaware 19898

ORSANCO Monitoring System
Ohio River Valley Water Sanitation Commission
Cincinnati, Ohio 45202

National Oil and Hazardous Materials Contingency Plan

Recognizing the need for a contingency plan, Congress passed the Water Quality Improvement Act of 1970, calling for the development of what is now the National Oil and Hazardous Materials Pollution Contingency Plan. The primary aim of this plan is to provide for coordinated and integrated responses to pollution spills by agencies and departments of the Federal government.

This national plan identifies two levels of authority, the national and regional levels, leaving the task of subregional development to regional officials and local groups. The highest level of control rests with the National Interagency Committee (NIC), comprised of representatives of five agencies: the Department of the Interior, the Department of Transportation (most notably, the U.S. Coast Guard), the Department of Defense, the Office of Emergency Preparedness, and the Department of Health, Education, and Welfare. NIC performs several basic functions beyond the promotion of coordinated responses of all Federal, state, and local governments and private agencies to pollution spills. The committee is continually involved with interpretation, revision and application of the national plan. It reviews and aids in the finalization of all regional plans, as well as coordinating reports from the National and Regional Response Centers (NRC and RRC) on handling of major incidents. This provides for continual evaluation of response effectiveness and provides vital data from summary reports. It is the responsibility of the committee to make recommendations related to training of response personnel, research, development, test, and evaluation activities needed to support response capabilities and equipment and materials stockpiling. Finally, the committee must establish and maintain liaison with the U.S. National Committee for the Prevention of Pollution of the Seas by Oil.

The physical facility for coordination of efforts requiring national level involvement is the National Response Center (NRC) housed in the headquarters of the United States Coast Guard in Washington, D.C. NRC utilizes trained personnel from the primary agencies to maintain and operate information storage, charting and communication facilities and to serve in an advisory capacity for regional response activities as well as in a directive capacity when the situation demands it.

In the event that an incident is beyond the capabilities of a region to respond, crosses regional boundaries, or poses a major threat to national security and/or significant numbers of people and property, the plan provides that a National Response Team (NRT) form the nucleus of the response personnel, thus relieving regional officials of final authority. Although the NRT also reviews daily reports from regional personnel on smaller incidents, without official activation, they can only advise and request further information. Thus, complete authority rests with the On-Scene Commander (OSC) in dealing with regional spills.

Analogous to the NRC and NRT are Regional Response Centers (RRC) and Regional Response Teams (RRT). While its functions are similar to those of its national counterpart, the RRT has additional responsibilities in that it must first declare that a pollution incident exists, determine the duration and extent of the Federal response, and finally whether a shift of on-scene coordination from the predesignated OSC is necessary. The regions themselves are those standard regions developed for purposes of general Federal administration unless otherwise specified by the Departments of Interior and Transportation.

One of the major features of regional plans will be the predesignation of an On-Scene Commander (OSC), the single executive responsible for determination of all pertinent facts concerning a particular spill. It falls upon the OSC to direct deployment of needed resources and personnel, document activities, and interact with the RRT. The documentation of activities will supply the basis of a summary report to be filed by the OSC at the conclusion of Federal activity resulting from a pollution incident. In most cases, the OSC will be a Coast Guard officer unless the spill occurs in an area where no Coast Guard personnel are stationed; in which case, a Department of the Interior official will take command. In the event of a spill at any location, the first Federal official at the site will assume authority until the designated OSC arrives.

The National Contingency Plan divides response action into five relatively distinct operational phases.

Phase 1 deals with discovery and notification of a spill. Discovery may come as the result of deliberate monitoring procedures or may be the outcome of random observations. While deliberate discoveries will automatically be channeled through the RRC, it is important that regional plans provide for the channeling of random observations to the RRC. Once the OSC has arrived at the scene, he will evaluate the severity of the spill and determine the reporting procedure to be followed for notification of participating Federal agencies. The exact alerting procedures and communication links to be employed for this notification should be specified in the regional plans.

Phase 2 concerns the defensive actions of containment and countermeasures designed to minimize damaging effects of the spill. These measures would include specific action to eliminate the source of the spill to prevent the occurrence of a situation hazardous to public health and to reduce the spread of the spill. Concurrently, a program of continual surveillance would be initiated to provide up-to-date information on the effects of the spill.

Phase 3 is comprised of those activities dealing with cleanup and disposal of the spilled material. As the plan is now constituted, it specifies booming, skimming, and sorbing of the pollutant. Such measures may be effective for oil and some insoluble chemicals, but fall far short for the large majority of materials which are soluble and toxic in the aquatic environment. For these chemicals, cleanup and disposal may well be an academic point. Regulations are given as to use of any chemical aids, use of which is governed by the Federal Water Quality Administration.

Phase 4 deals with the restoration of the environment to pre-spill conditions. This may involve actions such as replacement of contaminated beach sand.

Phase 5 encompasses the recovery of damages to Federal, state, or local government property and enforcement under proper authority such as the Federal Water Pollution Control Act, the 1899 Refuse Act, or state and local statutes and ordinances which apply. This phase also calls for the collection of scientific and technical data for the enhancement of knowledge of the environment and hazardous materials effects thereon.

The agency supplying the OSC is responsible for Phase 1, while Phases 2-4 are the OSC's direct responsibility. Phase 5 activities will be carried out by individual agencies according to existing statutes. It should be noted, that for many minor incidents, it is expected that the agent responsible for the spill will take appropriate actions to clean up the spill and restore the area to its prespill conditions. Under such circumstances, the majority of Federal action will consist of monitoring and reporting.

The plan calls for members of the NRT and RRT to notify their respective counsels upon declaration of a pollution incident. Initially, the counsel representing the agency responsible for selection of the OSC will coordinate all legal efforts. Responsibility then shifts to the counsel representing that agency with cost recovery or enforcement authority. The OSC's parent agency is also responsible for notification of the operator of the ship or facility at fault. This notification will point out Federal statutes and regulations violated, indicate responsibility for cleanup, and direct the operator to coordinate all response activity through the OSC. Phase 5 actions may further include boarding of vessels or visiting facilities, questioning personnel involved, issuance of pertinent warnings, acceptance of written or oral statements concerning the incident, and collection of all evidence in cases of unknown cause. The plan further specifies the procedure for the collection of samples and photographs.

In addition to the aforementioned chain of command, the National Plan calls for the deployment of a national level strike force whose function will be that of aiding any regional team when requested by the appropriate Coast Guard District Commander. Functioning under the OSC, the strike force will direct operation of any government-owned specialized pollution cleanup equipment. Similarly, regional plans are to designate local strike forces. Finally, all port areas designated as major ports by the President of the United States will establish emergency task forces of trained personnel, adequate oil pollution control equipment and material, and a detailed oil pollution prevention and removal plan. While designed to function primarily in their designated port area, these task forces should be prepared to assist in integrated efforts with national and regional strike forces.

To accommodate the flow of information to the public, the plan calls for the creation of a National and Regional News Office in the event of a major spill. News will be released through this organization structure to keep the nation current on the events of the spill and the subsequent response. Special arrangements are specified for keeping Senators, Representatives, Congressional Aids, White House Representatives, and other appropriate officials informed of all developments.

Since the primary thrust of the plan is to encourage the agent responsible for a spill to take appropriate remedial actions, it is assumed that all related costs of Phases 2-4 will be borne by that agent. Expenditure of money by Federal agencies will be totally reliant on the funds made available to that agency through existing authority.

As a result of the limited funds involved, the plan encourages the development of state and local plans to meet any and all minor spills. This puts the Federal response mechanism in the position of backstop for locally based operations on minor spills and primary defense for all major or multi-regional spills.

Regional, State, and Local Contingency Plans

Existing regional, state, and local contingency plans vary greatly in both rigor and scope. Some plans are firm and readily implemented while others are still in the formative stage. Since it would be unrealistic to describe all existing plans, those regarded as representative have been selected and are reviewed below.

Ohio Basin Region

The scope of the Ohio Basin Region Contingency Plan reflects the size of the region involved. Rather than dealing with specific details, it focuses first on a summary of the National Plan and then on enumeration of subregional information.

For each subregion, the plan denotes the name, address, and telephone number of all chain and command officials, local action groups, Federal laboratory facilities available for sample analysis, oil retention and reclamation equipment, Weather Bureau members, and emergency task force personnel and equipment.

The format of the plan encourages the development of sub-regional plans whose scope would include communication systems, further detailed equipment and personnel resources, and suggested preventative measures.

Maine

Due to the relatively small size involved and the existence of but one major port, Maine's contingency plan puts into concise and manageable form detailed information for rapid response to spills.

The plan provides a petroleum handling schedule suggested for acceptance by local port authorities as the guideline regulations. Through such a preventative posture, the plan hopes to reduce ship-to-ship, ship-to-shore, and shore-to-ship material handling spills.

Defensively, the plan lists suggested equipment for containment, removal, and disposal of spilled materials. The list consists of containment devices, absorbants, collection devices, and sinking agents pertaining to treatment of petroleum spills. The plan further suggests the establishment of local manpower and communication networks. It lists available manpower pools common to all township areas, i.e., police department, fire department, etc., as well as local officials who should be notified upon detection of a spill. While these arrangements are designed for minor spills, a detailed list of state officials and telephone numbers is provided for immediate notification in the event of a major spill. This listing includes State Environmental Improvement Commission officers, the Federal Water Quality Administration, the U.S. Coast Guard, State Civil Defense, and State Police. The plan also provides for a set radio frequency to be used by private personnel in reporting a spill.

The remainder of the minor spill procedure description includes an inventory of equipment available in Portland, Maine, a summary of FWQA policy on chemical treatment of spills, recommended methods for cleaning oil soaked birds, and an outline of the responsibilities of the personnel and agencies expected to participate in the spill response.

Finally, to assist in the response to major spills, the plan lists all personnel who may need notification on the subdistrict level. This includes district wardens, pollution abatement committees, and related industries. It enumerates ships and facilities available, personnel links in the State Civil Defense Communication network, Basic Emergency Operation Stations, and petroleum handling vessels and facilities operating in and around the state.

It is evident that the plan encompasses a small enough area that local planning can be complete and pertinent listings can provide most of the information required to make this response effective.

Louisiana Waterworks Warning Network Plan

A growing number of incidents of taste and odor impairment of water quality from accidental industrial releases prompted the Louisiana State Department of Health to devise a warning network plan to provide domestic water supply operators with ample time to counteract chemical contaminants or shut down intakes before public water is adversely affected. Past experience has shown the plan to be effective and present indications are that it will integrate well with Civil Defense functions, should the need arise.

The system consists of a network of telephone communication links. Upon discovery of water quality impairment, water plant operators are instructed to call State Department of Health officials. At that time, the Department of Health assumes responsibility for notifying downstream users beginning with the one immediately below the plant originating the report. Concurrently, the Department of Health is required to contact the Stream Control Commission to aid in a coordinated investigation of the source of the pollution. It is assumed that whenever an industry is aware of a discharge, it will contact the Stream Control Commission or Health Department and warn downstream users of the impending danger.

The System maps and lists plant locations, personnel, their respective telephone numbers, and Health Department officials so that the network plan carries with it all pertinent information for an early warning.

The type of localized information involved in such a system is exactly what is required for the effective use of any water quality contingency plan. The construction of sub-levels such as this across the country would tie in well with a full national plan. The national plan could deal with inter-sectional administration and common information banks concerning chemicals and their hazards, while the local groups maintained the alerting network.

Port of Los Angeles

The Port of Los Angeles Oil Spill Contingency Plan was developed to interact smoothly with the United States Coast Guard Oil Spill Abatement Operations and the State of California Spill Disaster Contingency Organization, when activated. The entire operation is placed under the direction of the port warden.

That portion of the plan dealing with prevention is comprehensive, reflecting the workable size of the area involved. Reliance is placed on the Los Angeles Municipal Code and the Port of Los Angeles Tarriff No. 3 to regulate all loading, unloading, and handling procedures as well as equipment and accident reporting procedures.

One of the primary duties of the uniformed force under the command of the port warden is the observation and reporting of spills. This function is carried out in conjunction with the Los Angeles Fire Department fire prevention inspectors.

Actions to be taken by the Master, owner, operator or agent of a vessel involved in an incident are outlined in the plan. These actions relate to reporting, containment, and removal of oil, petroleum, and petro-chemicals. Communications are handled through the Port of Los Angeles Communications Control Center located in San Pedro.

In the event that response to a spill is not being handled by private agents, the port warden directs the activities of his deputies who will function to assist fire personnel in setting of booms and assessing the severity of the spill. Simultaneously, steps will be taken to control nearby boat traffic in order to avoid additional injury or damage from explosion or fire. Deputy wardens are also assigned to obtain samples, witness statements, and obtain information related to the cause, source, amount, and composition of the material spilled. These wardens are required to report progress and maintain a working relationship with other agencies involved in this incident.

Finally, the plan presents an inventory of equipment available in the Port of Los Angeles to assist in oil spill abatement and pollution control operations as well as a list of petroleum product handling terminals and their available equipment.

Kanawha Valley, West Virginia Industrial Cooperative

In addition to the national, regional, state, and local contingency plans available for emergency response, there are a great number of industrial cooperatives designed to establish emergency procedures for the area around their industrial complex. One such organization is the Kanawha Valley Industrial Emergency Planning Council.

The council was originally formed to establish procedures to eliminate traffic problems during emergency situations. Since then, it has evolved into a working organization made up of qualified members from any company producing hazardous materials, utilities, or facilities employing more than 250 people.

Standing committees are appointed to probe individual aspects of emergency procedures. The membership and By-Laws Committee concerns itself with eligibility and recruitment of members and non-voting associate members. The Security and Traffic Control Committee carries out the original duties of the council. Plans have been developed whereby operating zones within the valley can be closed on receiving a report of an emergency situation. Special passes are issued for key personnel and utilities operators. Factory guards are provided to aid police in barricading and checking passes.

A network of ground communications has been established to maintain contact during emergencies. Special arrangements have been made to provide quick hook-up service with local radio stations to broadcast news and encourage low road and telephone usage by unauthorized personnel. The Material Assistance Committee functions to promote inter-company material assistance, while the Risk Evaluation Committee is available upon request to review and recommend handling procedures for potential hazardous operations.

It is the function of the Public Relations Committee to keep neighboring inhabitants aware of the program and services provided by the council so that they can both appreciate the precautions being taken and be knowledgeable should a disaster occur. The Special Services Committee acts as a liaison with outside agencies involved with emergency response such as the Red Cross and State Civil Defense organizations.

Councils such as this are designed to cope with factory emergencies. However, they provide an excellent administrative framework and procedural plans to meet disasters of all kinds. Organizations of this type could form a sound foundation for the local mechanism of a national plan.

ORSANCO

An advanced monitoring system is now in use in the Ohio River Basin under the control of the Ohio River Valley Water Sanitation Commission (ORSANCO)(1). Manual stations and robot monitors sample stream water to detect contamination from unreported leaks and pipeline breaks. Detection devices record DO, pH, Cl^- concentration, temperature, oxidation-reduction potential, conductivity, and solar radiation along the Ohio River and its tributaries, Should a spill be detected, activation of a communication system then insures that downstream users are informed of the spill and personnel are dispatched to the field to discover and stop the source. ORSANCO has responded to phenol, aniline, petroleum, and acid drainage spills that were not discovered by any other mechanisms.

Industrial Response Systems

Industry was the first to realize the hazards of bulk chemical handling and shipment, mainly as a result of efforts to achieve safe operation within production facilities. Consequently, industries have both singly and jointly established programs to respond to accidental spills of hazardous materials. The two most comprehensive systems are the ChemTREC response system maintained by the Manufacturing Chemists Association, and the Pesticide Safety Team established by the National Agricultural Chemists Association.

ChemTREC, which should be completely operable in 1971, is part of a diversified effort to minimize transportation disasters. The MCA sponsors several preventative programs as a first line defense. Chemicals are divided into specific hazard classes which can be denoted by colors, numbers, or key words on vehicle placards and shipment containers. These serve to warn handlers and the public of the type of chemical being transported and the hazards involved. They further serve as guides to indicate the nature of the cargo in the event of a disaster such as a train wreck.

Once a spill has occurred, ChemTREC (Chemical Transportation Response Emergency Center), moves into action. Initial contact is made by calling a predetermined telephone number which can be reached from any location in the country. The number is printed on chemical way bills and placards as well as on circulars given to transportation personnel. This funnels all reports into a central phone system which is manned 24 hours a day.

The attendant receiving the call immediately identifies the chemicals involved, the circumstances, the environment, and other pertinent information. He then contacts the company whose product is involved and other associated interests. This provides three sources of aid to combat the spill. The center then relays emergency instructions and precautions to personnel at the spill site. Although the center locates regional personnel to contact spill officials, it does not actually send people. It functions as an information and communication hub. Depending on the severity of the spill, officials of the responsible company and/or associated interests may or may not go to the site to assist with cleanup and containment operations. Following this initial response, the center is no longer involved in direct action.

Since ChemTREC is a cooperative effort, response to spills cuts across company lines. Any of the nine major companies in the MCA can be called upon to respond to a spill, while smaller signatory companies will respond only to spills of their own products.

Two major weaknesses of this system have been identified to date: reliance on the telephone, and the confusion of chemical names which often leads to inappropriate directions from the center. It has been suggested that way bills and placards use numbers to identify compounds in an attempt to alleviate this second problem.

Forerunners of ChemTREC include systems devised by several companies. These include Union Carbide's HELP program, American Cyanide's TWERP program and DuPont's TERP system. These systems are hot-line services that function to generate pertinent information from production and transportation personnel relaying it to the spill site with decontamination crews. These programs are now being integrated into the ChemTREC program. All of these systems are refinements of the TERP program, illustrated in Figure G-1, which was initiated by E. I. DuPont de Nemours & Company in April 1967.

The Pesticide Safety Team (PST) functions in a similar fashion. Preventative measures include a container inspection system, a non-technical safety manual, and a training film for carrier and warehouse personnel. The safety network itself notifies regional representatives when a spill is reported. A regional agent can then give specific advice on the pesticide spill as well as activate a safety team to neutralize the spilled agent and dispose of the contaminated material. The response procedure is illustrated in Figure G-2. Due to the extremely hazardous nature of agricultural chemicals, the PST responds to spills of all sizes. In fact, a large number of incidents involve accidents with containers in the 5-50 gallon capacity range.

Responding to spills in this manner can be risky from a legal standpoint. Individual companies must be aware of the liabilities involved. There is a danger that when the manufacturer of the spilled agent agrees to manage the cleanup operation it may be construed as acceptance of liability for the spill. This can force companies into a defensive position. Reluctance on the part of industry to respond could cause serious delays. This is a point that deserves further deliberation.

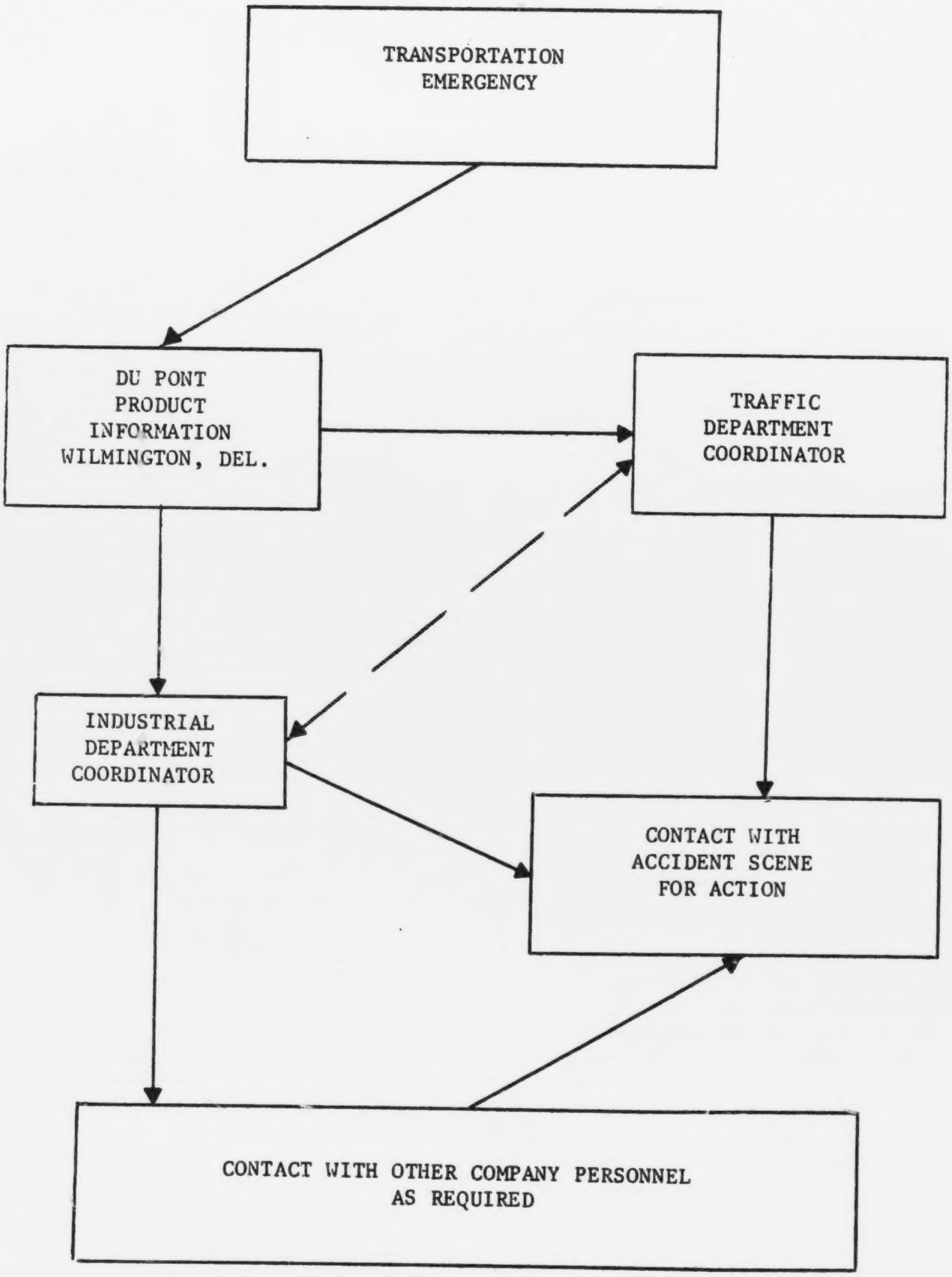
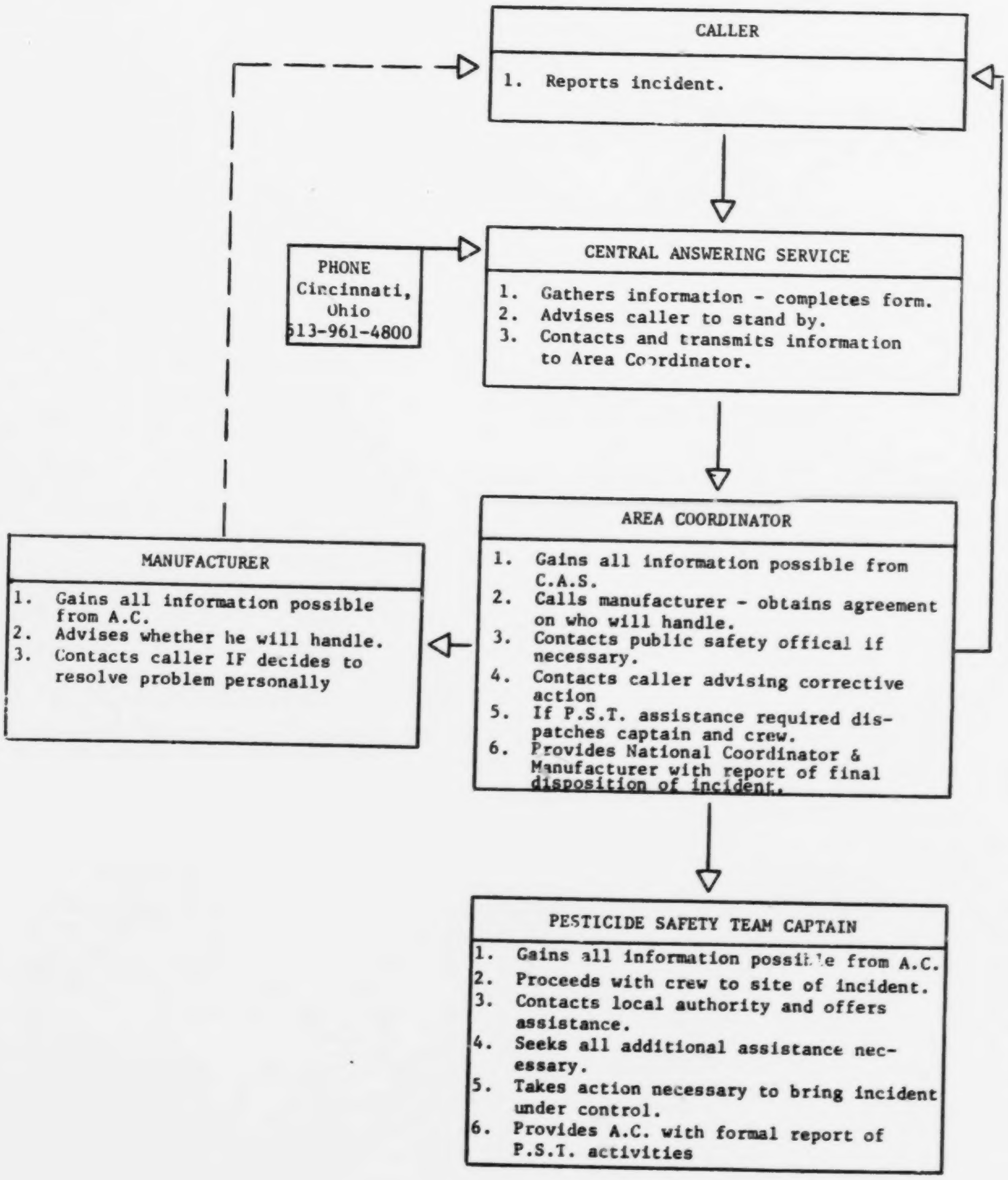

TRANSPORTATION EMERGENCY
DU PONT PRODUCT INFORMATION WILMINGTON, DEL.
TRAFFIC DEPARTMENT COORDINATOR
INDUSTRIAL DEPARTMENT COORDINATOR
CONTACT WITH ACCIDENT SCENE FOR ACTION
CONTACT WITH OTHER COMPANY PERSONNEL AS REQUIRED

FIGURE G-1. DuPont TERP Program(97)



CALLER

1. Reports incident.

CENTRAL ANSWERING SERVICE

1. Gathers information - completes form.
2. Advises caller to stand by.
3. Contacts and transmits information to Area Coordinator.

PHONE
Cincinnati, Ohio
513-961-4800

AREA COORDINATOR

1. Gains all information possible from C.A.S.
2. Calls manufacturer - obtains agreement on who will handle.
3. Contacts public safety offical if necessary.
4. Contacts caller advising corrective action
5. If P.S.T. assistance required dispatches captain and crew.
6. Provides National Coordinator & Manufacturer with report of final disposition of incident.

MANUFACTURER

1. Gains all information possible from A.C.
2. Advises whether he will handle.
3. Contacts caller IF decides to resolve problem personally

PESTICIDE SAFETY TEAM CAPTAIN

1. Gains all information possible from A.C.
2. Proceeds with crew to site of incident.
3. Contacts local authority and offers assistance.
4. Seeks all additional assistance necessary.
5. Takes action necessary to bring incident under control.
6. Provides A.C. with formal report of P.S.T. activities

FIGURE G-2. Emergency Procedure for Handling Accidental Spills of Class B Poison Pesticide Chemicals(55)

APPENDIX H

AGENCIES CONTACTED

Table H-1 lists the contacts made during the course of this study. The individual state agencies listed were initially contacted through the letter entitled Exhibit H-1 in this Appendix. Table H-2 is based on the responses received as a result of this letter and subsequent phone calls. The category entitled "Appear to have working program" was checked when the state response indicated that they were duly concerned with the problem of hazardous material spills and had initiated some type of action to provide better control and reporting. The vast majority of states appeared to have little knowledge of what was being transported across their borders and what could be done to minimize environmental damage.

TABLE H-1. Agencies and Organizations Contacted

FEDERAL GOVERNMENT

Executive Office of the President

Office of Emergency Preparedness
Disaster Assistance Division
Washington, D. C.

Library of Congress

Environmental Policy Division
Washington, D. C.

Department of Commerce

Office of Assistant Secretary for Science and Technology
Washington, D. C. 20004

Maritime Administration
Ports and Systems Division
Washington, D. C.

Department of Defense

U. S. Army Corps of Engineers
Board of Engineers for Rivers and Harbors
New Orleans, Louisiana

Operations Division, Civil Works
Washington, D. C.

Permanent International Association of Navigation Congresses
Board of Engineers for Rivers and Harbors
Washington, D. C.

Office of Civil Defense

TABLE H-1. (continued)

Department of Health, Education and Welfare

U. S. Public Health Service
    Environmental Health Service
    Washington, D. C.

Bureau of Solid Waste
    Cincinnati, Ohio

Department of the Interior

Office of the Assistant Secretary of the Interior
    for Water Quality and Research

Fish and Wildlife Service

    Bureau of Commercial Fisheries
        Gulf Breeze Laboratories
        Sabine Island, Florida

        Biological Laboratory
        St. Petersburg, Florida

        Galveston Laboratory
        Galveston, Texas

        Biological Laboratories
        Milford, Connecticut 06460

    Division of Pesticide Registration
    Washington, D. C.

Office of Oil and Gas
    Transportation and Storage Section
    Washington, D. C.

Geological Survey
    Hydraulics Section
    Washington, D. C.

TABLE H-1. (continued)

Federal Water Quality Administration
Division of Technical Support
Arlington, Virginia

Edison Water Quality Laboratory
Edison, New Jersey 08817

Northeast Region
Boston, Massachusetts 02203

Middle Atlantic Region
Charlottesville, Virginia 22901

Southeast Region
Atlanta, Georgia 30309

Ohio Basin Region
Cincinnati, Ohio 45226

Great Lakes Region
Chicago, Illinois 60605

Missouri Basin Region
Kansas City, Missouri 64106

International Sanitation Commission
Rochester, New York 14612

National Field Investigation Center
Cincinnati, Ohio 45213

Enforcement Branch
Washington, D. C.

Office of Water Resources Research
Water Resources Scientific Information Center
Washington, D. C.

Department of State

Bureau of International Scientific and Technological Affairs
Office of Environmental Affairs
Washington, D. C. 20520

Office of Maritime Affairs
Washington, D. C. 20025

TABLE H-1. (continued)

Department of Transportation

Federal Highway Administration

Bureau of Motor Carrier Safety
Washington, D. C. 20591

Federal Railway Administration

Bureau of Railroad Safety
Washington, D. C. 20591

Office of the Secretary

Office of Pipeline Safety
Washington, D. C.

Office of Hazardous Materials
Washington, D. C.

Office of Transportation Information
and Planning
Washington, D. C.

National Highway Safety Bureau
Office of State and Community
Comprehensive Planning
Washington, D. C.

National Transportation Safety Board
Bureau of Surface Transportation Safety
Washington, D. C.

U. S. Coast Guard

Office of Merchant Marine Safety
Washington, D. C.

FEDERAL GOVERNMENT RELATED

Smithsonian Institute

Center for Short-lived Phenomena
Cambridge, Massachusetts 02138

TABLE H-1. (continued)

National Academy of Sciences/National Research Council

Committee on Hazardous Materials
Advisory to U. S. Coast Guard
Washington, D. C.

STATE GOVERNMENT AGENCIES

Alabama

Water Improvement Commission
Montgomery, Alabama 36104

Arizona

Division of Soil and Water Conservation
Phoenix, Arizona 85009

Arkansas

Pollution Control Commission
Little Rock, Arkansas 72202

California

Department of Agriculture
Sacramento, California 95814

State Water Resources Control Board
Sacramento, California 95814

Department of Fish and Game
Sacramento, California 95814

The Resources Agency
Division of Public Health

Department of Justice
Deputy Attorney General

Regional Water Quality Control Board
Los Angeles, California

State Highway Patrol
Sacramento, California

California Disaster Office
Sacramento, California

TABLE H-1. (continued)

Colorado

Water Conservation Board
Denver, Colorado 80203

Connecticut

Water Resources Commission
Hartford, Connecticut 06115

Delaware

Water and Air Resources Commission
Dover, Delaware 19901

Florida

Department of Air and Water Pollution Control
Tallahassee, Florida 32301

Department of Health and Rehabilitation Service
Division of Health
Jacksonville, Florida 32201

Georgia

Water Quality Control Board
Atlanta, Georgia 30334

Idaho

Department of Health
Boise, Idaho 83707

Illinois

Sanitary Water Board
Springfield, Illinois 62706

Indiana

Stream Pollution Control Board
Indianapolis, Indiana 46206

Iowa

Water Pollution Control Commission
Des Moines, Iowa 50319

Kansas

Department of Health
Topeka, Kansas 66612

TABLE H-1. (continued)

Kentucky

Water Pollution Control Commission
Frankfort, Kentucky 40601

Louisiana

Office of the Attorney General
Baton Rouge, Louisiana 70803

Louisiana Public Service Commission
Baton Rouge, Louisiana 70803

Louisiana State Police Headquarters
Baton Rouge, Louisiana 70803

Louisiana State Department of Health
New Orleans, Louisiana 70160

Louisiana Stream Control Commission
Baton Rouge, Louisiana 70803

Wildlife and Fisheries Commission
Baton Rouge, Louisiana 70803

Maine

Soil and Water Conservation Commission
Augusta, Maine 04330

Maryland

Department of Water Resources
Annapolis, Maryland 21401

Massachusetts

Division of Water Pollution Control
Boston, Massachusetts 02202

Michigan

Water Resources Commission
Lansing, Michigan 48926

Minnesota

Pollution Control Agency
Minneapolis, Minnesota 55440

TABLE H-1. (continued)

Mississippi

Air and Water Pollution Control
Jackson, Mississippi 39205

Missouri

Water Pollution Board
Jefferson City, Missouri 65101

Montana

Department of Health
Helena, Montana 59601

Nebraska

Department of Health
Lincoln, Nebraska 68509

Nevada

Bureau of Environmental Health
Carson City, Nevada 89701

New Hampshire

Water Supply and Pollution Control Commission
Concord, New Hampshire 03301

New Jersey

Department of Health
Trenton, New Jersey 08625

New Mexico

Health and Social Services Department
Santa Fe, New Mexico 87501

New York

Department of Environmental Conservation
Water Resources Division
Campus, Albany, New York 12226

TABLE H-1. (continued)

North Carolina

Department of Water and Air Resources
Raleigh, North Carolina 27603

North Dakota

Division of Water Supply and Pollution Control
Bismarck, North Dakota 58501

Ohio

Attorney General's Office

Department of Health
Columbus, Ohio 43216

Department of Natural Resources
Columbus, Ohio 43216

Division of Wildlife

Ohio Public Utilities Commission
Superintendent of Motor Transportation
Railroad Department

Oklahoma

Water Quality Control Division
Oklahoma City, Oklahoma 73105

Oregon

Department of Environmental Quality
Portland, Oregon 97207

Pennsylvania

Office of the Attorney General
Harrisburg, Pennsylvania 17120

Sanitary Water Board
Harrisburg, Pennsylvania 17120

Fish Commission
Harrisburg, Pennsylvania 17120

Puerto Rico

Department of Health
San Juan, Puerto Rico 00908

TABLE H-1. (continued)

Rhode Island

Division of Water Pollution Control
Providence, Rhode Island 02903

South Carolina

Pollution Control Authority
Columbus, South Carolina 29201

South Dakota

Committee on Water Pollution
Pierre, South Dakota 57501

Tennessee

Stream Pollution Control Board
Nashville, Tennessee 37219

Texas

Water Quality Board
Austin, Texas 78701

Utah

Department of Natural Resources
Salt Lake City, Utah 84114

Vermont

Water Supply and Pollution Control Division
Montpelier, Vermont 05602

Virginia

State Water Control Board
Richmond, Virginia 23230

Washington

Water Pollution Control Commission
Olympia, Washington 98501

West Virginia

Department of Natural Resources
Charleston, West Virginia

Wisconsin

Bureau of Water Supply and Pollution Control
Madison, Wisconsin 53701

TABLE H-1. (continued)

Wyoming

Department of Health and Social Services
Cheyenne, Wyoming 82001

Interstate Agencies and Commissions

Bi-State Development Agency
St. Louis, Missouri 63100

Delaware River Basin Commission
Trenton, New Jersey 08603

Great Lakes Commission
Ann Arbor, Michigan 48105

Interstate Sanitation Commission
New York, New York 10019

Interstate Commission on the Potomac River Basin
Washington, D. C. 20005

Klamath River Compact Commission
Sacramento, California 95814

New England Interstate Water Pollution Control Commission
Boston, Massachusetts

Ohio River Valley Water Sanitation Commission (ORSANCO)
Cincinnati, Ohio 45216

Resources Advisory Board Southeast River Basin
Atlanta, Georgia 30303

Tennessee River Basin Water Pollution Control Commission
Nashville, Tennessee 37219

Upper Colorado River Commission
Salt Lake City, Utah 84111

Water Resources Association of The Delaware River Basin
Philadelphia, Pennsylvania 19107

TABLE H-1. (continued)

Industrial Associations and Technical Societies

American National Standards Institute
New York, New York

American Association of Port Authorities
Washington, D. C. 20005

American Chemical Society
Committee on Chemical Safety
Washington, D. C.

American Insurance Association
Engineering and Safety Department
New York, New York

American Petroleum Institute
Transportation Department
Washington, D. C.

American Trucking Associations
National Tank Truck Carriers, Inc.
Washington, D. C. 20036

American Waterways Operators Association
Washington, D. C.

Association of American Railroads
Bureau of Explosives
Edison, New Jersey

Chemical Specialties Manufacturing Association
New York, New York

Chlorine Institute
New York, New York

Compressed Gas Association
New York, New York

Manufacturing Chemists Association
Safety and Fire Protection
Washington, D. C. 20009

National Agricultural Chemical Association
Washington, D. C. 20005

TABLE H-1. (continued)

Commercial Firms, Port Authorities and Others

E. I. duPont de Nemours and Company
Operations Division
Wilmington, Delaware 19898

Hercules, Incorporated
Safety Department
Wilmington, Delaware 19899

Hooker Chemical
Environmental Health Department
New York, New York 10017

Port of Houston
Houston Ship Channel Cooperative
Houston, Texas 77001

Port of Los Angeles
San Pedro, California 90733

Port of New York Authority
Planning and Development Department
New York, New York 10011

Southern Railway System
Safety Planning Department
Atlanta, Georgia 30303

Stauffer Chemical Corporation
Agricultural Research Center
Sunnyvale, California

Union Carbide Corporation
Technical Center
South Charleston, West Virginia 25303

American Cyanamid Company
Safety and Loss Prevention
Wayne, New Jersey

Colonial Pipe Lines
Atlanta, Georgia

TABLE H-1. (continued)

Foreign Agencies

International Maritime Consultation Organization
Cargoes and Related Matters Section
London W. 1, England

STICHTING Concawe
The Hague, Netherlands

EXHIBIT H-1

FORM LETTER SENT TO STATE AGENCIES

As you are perhaps aware, the Water Quality Improvement Act of 1970 requires a report to the Congress on the control of hazardous polluting substances by November 1, 1970. In this connection, the Federal Water Quality Administration, through the Division of Applied Science and Technology, has engaged Battelle-Northwest to assemble information and analyses pertinent to documented and potential pollution by hazardous materials as specifically related to water quality problems. A copy of the scope of work as specified by FWQA is attached, along with an indication of key considerations and information needs. In this review, we are not concerned with chronic releases of hazardous materials and wastewaters, but rather with acute releases such as through transportation, loading and unloading, and storage incidents and how to control or mitigate their effects.

The subject of hazardous materials as they may affect water quality is complex, and even the definition and identification of these materials is difficult. Therefore, as a starting point, we are using the list of materials prepared by the National Academy of Sciences/National Research Council Committee on Hazardous Materials as a base line and deleting from, or augmenting this list based on net water quality threat and other information as may be developed in the course of the program. For example, pesticides and other economic poisons are not included in the NAS/NRC list but represent an already well-demonstrated threat.

Obviously, materials which may be a potential water quality problem in one area may not be a significant problem in another, due to variations in material use and the nature of water bodies in the area. Therefore, we are soliciting relevant information on a regional as well as national basis.

Specifically, we would appreciate information on the following:

1. Identification of hazardous polluting materials in commercial trade potentially released to water in the State of Illinois. A priority ranking would be highly desirable.
2. Estimates of quantity of the materials identified above.
3. Nature of water bodies (river, impounded water, estuary, etc.) potentially damaged and the nature of resources threatened.
4. Past experiences in acute pollution incidents particularly as related to control measures and effectiveness.
5. Contingency and response plans in effect: Federal, state, private, or local.
6. Contacts and information sources in both public and private agencies that could provide detailed information on the above items.
7. Personnel within your organization that should be contacted for further discussion.

The complexity of this program is great and the time available is limited; thus, we would appreciate any input that your organization can provide as soon as possible. If it appears appropriate, we would be pleased to meet with you and your staff at your offices. Should you have any questions, please feel free to call me on (509) 946-2229. Thank you in advance for any assistance you can provide.

TABLE H-2. State Responses to Hazardous Material Inquiry

State	Letter Sent	Response Received	Appear to have working program	Supplied list of incidents
Alabama	x			
Alaska				
Arizona	x	x		
Arkansas	x	x		
California	x	x	x	x
Colorado	x	x		
Connecticut	x			
Delaware	x			
Florida	x	x	x	
Georgia	x	x		
Hawaii				
Idaho	x			
Illinois	x	x	x	x
Indiana	x			
Iowa	x			
Kansas	x			
Kentucky	x			
Louisiana	x	x	x	
Maine	x	x		
Maryland	x	x		
Michigan	x			
Minnesota	x	x		
Mississippi	x	x		
Missouri	x			
Montana	x	x		
Nebraska	x	x		
Nevada	x	x		
New Hampshire	x			
New Jersey	x			
New Mexico	x	x		
New York	x	x	x	
North Carolina	x	x		
North Dakota	x			
Ohio	x	x	x	
Oklahoma	x			
Oregon	x	x	x	
Pennsylvania	x	x	x	x
Rhode Island	x	x	x	
South Carolina	X			
South Dakota	x	x		
Tennessee	x			
Texas	x			
Utah	x	x		
Vermont	x			
Virginia	x	x		
Washington	x			
West Virginia	x			
Wisconsin	x	x		
Wyoming	x	x	x	

APPENDIX I

REVIEW OF EXISTING STATUTES AND ENFORCEMENT POLICIES*

The following discussion of enforcement statutes is primarily concerned with state and federal statutes which are applicable in cases of spills of hazardous polluting substances. Emphasis is on laws which prohibit acts which will cause damage to the environment and which serve to recover damages and punish offenders. Following the discussion of Federal and State statutes, the rights of citizens to take action are discussed.

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* See footnote, section entitled "Legal and Enforcement Considerations," p. 73.

Federal Law

Federal Statutes

Federal Water Pollution Control Act, 33 USC 466.

Section 10 of this Act,(as amended) sets forth the principal enforcement authority of the Federal Government in controlling water pollution. This section provides for the establishment of water quality standards by the individual states, which must be approved by the Secretary of the Interior.

When approved by the Secretary, these standards become Federal law. Violation of water quality standards is subject to abatement in Federal Court six months after the polluter has been given notice and an opportunity to clean up the source of the violation.

Water Quality Standards, as presently constituted, provide for the regulation of toxic substances. All states have been required to adopt statements as a part of general standards applicable to all waters, which require that those waters be free of substances attributable to discharges or wastes which are toxic or which produce undesirable physiological responses in human, fish, and other animal life and plants. Some States have adopted specific criteria for certain heavy metals.

Under the general standard, any substance which has been demonstrated to be toxic to human, animal or aquatic life, or which can be assimilated and concentrated to toxic levels can be regulated. Within the present limits of the FWPC Act, the prescribed regulatory procedure can be initiated against any discharger of such toxic substances.

The procedure for regulating toxic substances under general water quality standards is fourfold:

1. Demonstrate that a substance is toxic (in any concentration or within certain limits) or may be concentrated by life cycle or other processes to toxic levels.
2. Show that a discharger is causing or contributing to the presence of that toxic substance.
3. Issue 180-day notice.
4. Seek court action, if voluntary compliance is not achieved.

This procedure does not necessarily preclude the identification in water quality standards of specific toxic substances or the advisability of such specific criteria. Once a substance has been demonstrated as toxic and limitations on in-stream levels have been identified, those substances are included as a part of each State's specific criteria. The regulatory procedure is then simplified to three steps:

1. Show that a discharger is causing or contributing to the presence of the toxic substance and the violation of the specific criteria.
2. Issue 180-day notice.
3. Seek court action, if voluntary compliance is not achieved.

A second enforcement device is provided by the Act in the enforcement conference. Here interstate pollution is recognized in a nonadversary setting in which the participants are the States in which the pollution is occurring and the Federal Government.

An even greater lapse of time must pass than in the case of a water quality standards violation before the polluter may be brought into court. Jurisdictional requirements for Federal legal action are also stringent.

The court is authorized in Section 10(h) as the final step in both procedures to grant any appropriate (civil) relief after "giving due consideration to the practicability and to the physical and economic feasibility of securing abatement of any pollution proved."

Section 10, despite the fact that some effort has been made in the water quality standards to control the discharge of hazardous polluting substances, was not designed specifically to deal with situations involving spills of hazardous materials. Thus, actions are authorized only to secure "abatement" of the pollution; imposition of liability for clean-up and restoration is seemingly excluded by the words of 10(h). Action against the polluter is deferred by a time delay of at least six months. Federal action is further impeded by strict jurisdictional tests and state priority. The provisions of Section 10 are presently of little use in the hazardous material spill area; they function better where the pollution is chronic and of a less toxic nature.

River and Harbor Act of 1899 (Refuse Act): The most effective Federal enforcement authority cases involving spills of hazardous polluting substances exists in Sections 13 and 16 of the River and Harbor Act of 1899 (Refuse Act). The refuse act prohibits the discharge of "any refuse matter of any kind or description," whether from a vessel or from the land, into any interstate or intrastate navigable water of United States or its tributary, except under a permit from the Corps of Engineers. Navigable waters, as presently defined for the purposes of the Act, include nearly all streams and waterways in the United States. Refuse material under this act, although specifically excluding municipal sewage, has been interpreted by the courts [U.S. v. Standard Oil Co. 384 US 244, (1966)] to include "all foreign substances and pollutants," even though they may be industrial chemicals or oils of commercial value.

Of further significance is the interpretation that discharges need not be willful or negligent to constitute a violation of the Refuse Act. Accidental and unintentional spills have been ruled unlawful by the courts [U.S. v. Interlake Steel Corp. 297 Fed. Supp. 912, N.D. Ill, (1969)].

On June 15, 1970, the Assistant Attorney General of the United States, Land and Natural Resources Division, published guidelines for application of the Refuse Act by U.S. Attorneys. The policy of the Department of Justice, as stated in the guidelines, is to use the Refuse Act to supplement the Federal Water Pollution Control Act by applying it only to punish the occasional or recalcitrant polluter, or to abate continuing sources of pollution which have not been subjected to FWQA or state proceedings, or where the polluter has failed to comply with obligations under such a procedure. The focus of the Assistant Attorney General's instructions was to:

> "... encourage United States Attorneys to use the Refuse Act to punish or prevent significant discharges, which are either accidental or infrequent, but which are not of a continuing nature resulting from the ordinary operations of a manufacturing plant."

One objective of this narrow application of the Refuse Act is to avoid interference in the functions of FWQA in programs dealing with continuous discharges. The application outlined by the Assistant Attorney General, although limiting enforement action under the act, clearly indicates that the federal government has the power to prosecute those who cause spills of hazardous materials, accidental or otherwise, and to act to prevent potential pollution. This act could be a useful tool in dealing with spills of hazardous polluting substances. An example of its use occurred in the recent prosecution of eight companies allegedly discharging mercury to navigable waters. Prosecution was recommended directly by the U.S. Department of Interior to the Justice Department. Civil injunctions against further discharge of mercury and removal of contaminated sediments was sought in each instance. Although no case was resolved by the decision of a court, quick action in abating the continuing discharge of an exceedingly toxic substance was noted in all cases.

Of course, the value of an injunction in a single spill situation is somewhat limited. Other relief, in the form of a criminal fire or recovery of clean-up and restoration costs, may be available in many spill situations, but Federal authorities do not view the Refuse Act as providing a comprehensive and adequate regulatory scheme for hazardous polluting substances spills. This will be true even after a new discharge permit system administered by the Corps of Engineers becomes fully operational.

This system, like the water quality standards structure, will be designed primarily to seek abatement of chronic or continual discharges.

The overriding defect in the Refuse Act--as in other existing Federal and State legislation--is that there is no provision for ensuring spill prevention. The Refuse Act penalizes a discharger after the offending act has occurred, but is virtually powerless to establish and enforce adequate preventive measures, particularly on an industry or nationwide basis. Moreover, the Act is administered principally by the courts, which must assess penalties and award damages. These tasks, as well as the establishment of preventive standards, might better be vested in an administrative agency.

Other Regulatory Authority

Transportation: Because a great potential for spills lies in transportation, the regulation of the transport of hazardous materials provides a significant and obvious area for preventing or minimizing damage spills.

As presently structured, hazardous materials transportation regulations are established and enforced on a modal basis. Each transportation agency within the Department of Transportation (Federal Highway Administration, Federal Railway Administration, and Office of Pipeline Safety) is responsible for establishing and enforcing hazardous materials safety regulations for carriers under their jurisdiction. The DOT Office of Hazardous Materials serves in an advisory capacity, but has neither regulatory authority nor enforcement personnel. No central regulatory program presently exists in DOT which has the power to coordinate regulatory efforts in all transportation modes with the objective of reducing incidents involving hazardous materials. Legislation is now before the 91st Congress which could provide the necessary authority.

Title II of Senate Bill 1933, which is entitled the "Hazardous Materials Transportation Control Act of 1969" which was cleared by Senate-House conferences on 12 September, 1970, requires the Secretary of Transportation to:

> (1) Establish facilities and technical staff to maintain within the Federal Government the capability to evaluate the hazards connected with and surrounding the various hazardous materials being shipped.
>
> (2) Establish a central reporting system for hazardous materials accidents to provide technical and other information and advice to the law enforcement and firefighting personnel of communities and to carriers and shippers for meeting emergencies connected with the transportation of hazardous materials.
>
> (3) Conduct a review of all aspects of hazardous materials transportation to determine and recommend appropriate steps which can be taken immediately to provide greater control over the safe movement of such materials.

While this act is only an attempt to further define the problem and provide some interim action, it demonstrates concern and could lead to tighter controls of hazardous material transport and better enforcement action.

Miscellaneous: Federal regulatory authority in the area of hazardous polluting substances appears in many other agencies and branches of the government. A partial listing includes:

1. 7 CFR Part 362-Regulations for the Enforcement of the Federal Insecticide, Fungicide, and Rodenticide Act. (Pesticides Regulation Division, Agricultural Research Service, U.S.D.A.)

   Includes provisions respecting mandatory labeling and registration.

2. 14 CFR Part 103--Transportation of Dangerous Articles and Magnetized Materials. (FAA.)

   Includes certification, packing and marking and labeling requirements.

3. 19 CFR Part 12--Special Classes of Merchandise. (Bureau of Customs, Department of the Treasury.)

   Includes regulations respecting import of Foods, Drugs, and Cosmetics; Economic Poisons; Hazardous Substances; Dangerous Caustic or Corrosive Substances; Viruses, Serums, and Toxins for treatment of domestic animals, and viruses, serums, toxins, antitoxins, and analogous products for the treatment of man.

4. 21 CFR Part 1--Regulations for the Enforcement of the Federal Food, Drug, and Cosmetic Act and the Fair Packaging and Labeling Act. (FDA.)

   Includes labeling and guarantees, prohibited acts and penalties.

5. 21 CFR Part 120--Tolerances and Exemptions from Tolerances for Pesticide Chemicals in or on Raw Agricultural Commodities. (FDA.)

   Includes definitions and specific tolerance levels for various residues.

6. 21 CFR Subchapter D (Part 191)--Hazardous Substances. (FDA.)

   Includes Definitions and Interpretations; Testing Procedures for Hazardous Substances, Exemptions; Labeling requirements; Procedural Regulations; Prohibited Acts and Penalties; Administration; and Imports.

7. 21 CFR Part 285--Regulations under the Federal Caustic Poison Act. (FDA.)

Includes labeling, sampling and inspection.

8. 30 CFR, various parts--Blasting devices. (Bureau of Mines.)

Includes Conditions under which various types of blasting devices may be approved and used.

9. 30 CFR Part 211--Coal-Mining Operating and Safety Regulations. Particularly Section 211.79 *et seq*.--Storage, Transportation, Distribution and Use of Explosives. (Bureau of Mines.)

10. 30 CFR Part 221--Oil and Gas Operating Regulations. (Geological Survey; Department of Navy.)

Applies to deposits and lands owned or controlled by the United States and under jurisdiction of the Secretary of the Interior or the Secretary of the Navy.

11. 30 CFR Part 231--Operating and Safety Regulations Governing the Mining of Potash; Oil Shale, Sodium, and Phosphate; Sulphur; and Gold, Silver, or Quicksilver; and Other non-Metallic Minerals, Including Silica Sand. (Geological Survey; Bureau of Mines.)

Applies to methods of mining on the public domain and includes welfare and safety; Mining methods; and Protection against mine hazards.

12. 32 CFR Part 301--Control of Explosives and their Ingredients in Time of War or National Emergency. (Bureau of Mines.)

Includes transportation, storage and handling of explosives.

13. 33 CFR Part 126--Handling of Explosives or Other Dangerous cargoes within or contiguous to waterfront facilities. (Commandant, District Commander or Captain of the Port.)

Includes permit authority.

14. 36 CFR Section 2.9--Explosives. (National Park Service.)

Prohibits use or possession of explosives or fireworks without permission of Superintendent.

15. 46 CFR Part 36--Elevated Temperature Cargoes
46 CFR Part 38--Liquified Flammable Gasses.
46 CFR Part 39--Flammable or Combustible Liquids Having Lethal Characteristics (Coast Guard).
46 CFR Part 40--Special Construction, Arrangement, and other provisions for carrying certain flammable or combustible dangerous cargoes in bulk.

Includes design specifications and inspections.

16. 46 CFR Part 98--Special Construction, arrangement, and provisions for certain Dangerous Cargoes in Bulk. (Coast Guard.)

Includes provisions respecting elemental phosphorous, sulfuric acid, hydrochloric acid, phosphoric acid, liquid chlorine and anhydrous ammonia, as well as provisions for Barges carrying Dangerous Cargoes and Portable Tanks for Combustible Liquids.

17. 46 CFR Part 146--Transportation or Storage of Explosives or Other Dangerous articles or Substances, and Combustible Liquids on Board Vessels. (Coast Guard.)

Includes extensive provisions "to promote safety in the handling, stowage, storage and transportation of explosives or other dangerous articles or substances, and combustible liquids, ...on board vessels on any navigable waters within the limits of the jurisdiction of the United States, including its territories and possessions excepting only the Panama Canal Zone and to make more effective the provisions of the the International Convention for the Safety of Life at Sea, 1960, relative to the carriage of dangerous goods." (Section 146.01-1.) Regulations define and classify dangerous substances and set forth general and specific requirements respecting transportation of such substances.

18. 46 CFR Part 147--Regulations Governing Use of Dangerous Articles as Ships' Stores and Supplies on Board Vessels. (Coast Guard.)

Includes certification and stowage.

19. PHS Drinking Water Standards (1962).

Include specific standards.

State Law

State of California

Department of Fish and Game: In California, the Fish and Game Code has provided the statutory authority for virtually every action brought for pollution of water by spillage of a hazardous material. Section 5650 of the code specifies the prohibition, stating:

> It is unlawful to deposit in, permit to pass into, or place where it can pass into the waters of this state any of the following:
>
> (a) Any petroleum, acid, coal or oil tar, lampblack, aniline, asphalt, bitumen, or residuary product of petroleum, or carbonaceous material or substance.
>
> (b) Any refuse, liquid or solid, from any refinery, gas house, tannery, distillery, chemical works, mill or factory of any kind.
>
> (c) Any sawdust, shavings, slabs, edgings.
>
> (d) Any factory refuse, lime, or slag.
>
> (e) Any cocculus indicus.
>
> (f) Any substance or material deleterious to fish, plant life, or bird life.

Section 12010 of the Fish and Game Code specifies that the minimum punishment for a violation of Section 5650 is a fine of $100 or imprisonment in the county jail for 25 days. The maximum criminal penalty is a fine of $1,000 and/or a jail term of one year. Section 12015 places an added requirement on an unlawful polluter:

> In addition to any other penalty provided, anyone convicted of unlawfully polluting, contaminating, or obstructing waters to the detriment of fish life in such waters, shall either be required to remove any substance placed in the waters, which can be removed, that caused the prohibited condition or to pay the costs of such removal by the department.

Court tests have upheld the right of the Department of Fish and Game to seek criminal prosecution under Section 5650. This department feels that the present statement of the law - Section 5650(f) of the Fish and Game Code - provides all the latitude needed in prosecuting for a hazardous spill. In a significant number of cases to date, the defendant has entered a nolo contendere or guilty plea. The fact that fish are killed is sufficient to establish liability. Problems arise not from sufficiency of the law, but from inability to trace down the root cause of a pollution incident "beyond a reasonable doubt." For every case in which positive proof of liability can be established, there are other cases which remain unsolved.

The Department of Fish and Game also recovers clean-up and damage costs by using the common law to take civil actions against those responsible. Many times, the settlement will be made out of court. Management personnel in the department have put a price tag on dead fish in some incidents, particularly where the fish can be replaced by a hatchery and the exact replacement cost is known. It was agreed that damage due to loss of a beneficial use, or due to loss of a food chain, is more difficult to assess; however, the department is considering the use of an economist to perform such assessments.

Enforcement which relates to the Fish and Game Code is always after the fact, since action is taken after a result - usually dead fish - is observed. The Department of Fish and Game nearly always has the right of action, since, in California it has been established that the state is presumed to be the owner of the fish. If the water involved were to be a private pond, however, the individual injured could seek civil action. There have been a few California cases in which private parties have gotten common law relief. Despite the fact that the law allows for action only after an incident occurs, officials in the Department of Fish and Game feel that awareness of the potential for public action does act as a deterrent to someone dealing with hazardous materials which have a potential for water pollution.

The California Water Code: For purposes of this study, the most important part of the Water Code is the Porter-Cologne Water Quality Control Act, which represented a major revision of California's water quality laws. The applicability of the Act to accidental spills of hazardous materials will be discussed. Since the Porter-Cologne Act became law only recently, in 1969, it has not yet been tested in court action against the particular type of problem which is being addressed here.

The Porter-Cologne Water Quality Control Act comprises Division 7 of the Water Code, commencing with Section 13000. Section 13002 reads:

> No provisions of this division or any ruling of the state board (State Water Resources Control Board) or a regional board (regional water quality control board) is a limitation:
>
> (a) On the power of a city or county or city and county to adopt and enforce additional regulations, not in conflict therewith, imposing further conditions, restrictions, or limitations with respect to the disposal of waste or any other activity which might degrade the quality of the waters of the state.
>
> (b) On the power of any city or county or city and county to declare, prohibit,and abate nuisances.
>
> (c) On the power of the Attorney General, at the request of a regional board, or upon his own motion, to bring an action in the name of the people of the State of California to enjoin any pollution or nuisance.
>
> (d) On the power of a state agency in the enforcement or administration of any provision of law which it is specifically permitted or required to enforce or administer.
>
> (e) On the right of any person to maintain at any time any appropriate action for neglect against any private nuisance as defined in the Civil Code or for relief against any contamination or pollution.

Section 13002(e), then, preserves the right of any individual to seek civil action if he is injured because of a spillage of a hazardous material.

Section 13304 states:

> (a) Any person who discharges waste into the waters of this state in violation of any waste discharge requirement or order issued by a regional board, or who intentionally or negligently causes or permits any waste to be deposited where it is discharged into the waters of the state and creates a condition of pollution or nuisance, shall upon order of the regional board clean up such waste or abate the effects thereof. Upon failure of any person to comply with such cleanup or abatement order, the Attorney General, at the request of the board, shall petition the superior court for that county for the issuance of an injunction requiring such person to comply therewith. In any such suits, the court shall have jurisdiction to grant a prohibitory or mandatory injunction, either preliminary or permanent, as the facts may warrant.
>
> (b) If such waste is cleaned up or the effects thereof abated by any governmental agency after issuance of a regional board cleanup or abatement order, such person shall be liable to that governmental agency to the extent of the reasonable costs actually incurred in cleaning up such waste or abating the effects thereof. The amount of such costs shall be recoverable in a civil action by, and paid to, such governmental agency and the state board to the extent of the latter's contribution to the cleanup costs from the State Water Pollution Cleanup and Abatement Account.

It was pointed out by water quality officials that a hazardous material spill could be construed as a violation of a waste discharge requirement, and that therefore resulting costs incurred could be collected under Section 13304. However, some determination would also have to be made as to whether the material discharged is actually "waste." This same question comes up with respect to Section 13340, which is also interpreted by some of the state's lawyers as a statute which can be applied to accidental incidents. Section 13340 provides:

> Whenever a regional board finds that a discharge of waste within its region is taking place or threatening to take place which does or will cause a condition of pollution or nuisance, constituting an emergency requiring immediate action to protect the public health, welfare, or safety, the Attorney General, upon request of the board, shall petition the superior courts to enjoin such discharge. The court shall have

> jurisdiction to grant such prohibitory or mandatory injunctive relief as may be warranted by way of temporary restraining order, preliminary injunction, and permanant injunction.

Section 13350, the only section of the Porter-Cologne Act to specify a particular civil monetary remedy ($6,000 per day), applies only to violation of a cease and desist order, and would therefore not be applicable to a single accidental occurrence. It is conceivable, though, that a series of "accidents" might lead to a cease and desist order.

The fact that those responsible for water quality in California are concerned with the water pollution potential of certain specific materials is being evidenced by recent legislation and regulation. One bill demonstrating this deals with the hauling of liquid wastes. This bill, passed by the legislature in August, 1970, makes it unlawful, with prescribed exceptions, for any person to carry on, or engage in, the business of hauling liquid waste unless he is registered with the State Water Resources Control Board. New section 14041 of the Water Code states:

> The hauler of liquid waste shall dispose of liquid waste in accordance with the regulations adopted by the regional board and on a site approved by the regional board and shall dispose of only such type of liquid waste as was designed for the particular site.

Section 14043 reads:

> Each person who provides liquid waste which is to be hauled in a vehicle prior to being discharged shall consign or deliver such waste only to a registered liquid waste hauler.

These new provisions of the law are specifically designed to prevent deleterious wastes from finding their way to either ground or surface water. Section 14080 specifies that anyone who violates sections 14041 or 14043 is guilty of a misdemeanor. Liquid waste is defined in section 14002 as including any solid or gaseous substances which may be contained in the liquid.

Other California Laws: The Harbors and Navigation Code contains a section which, although directed specifically to oil pollution, might be considered as an example of how a civil penalty could be applied to other hazardous materials which may become a particular source of pollution problems. Section 151 of this code states in part:

> ...any person that intentionally or negligently causes or permits any oil to be deposited in the water of this state, including but not limited to navigable waters, shall be liable civilly in an amount not exceeding six thousand dollars ($6,000) and, in addition, shall be liable to any governmental agency charged with the responsibility for cleaning up or abating any such oil for actual damages, in addition to the reasonable costs actually incurred in abating or cleaning up the oil deposited in such waters. The amount of the civil penalty which is assessed pursuant to this section shall be based upon the amount of discharge and the likelihood of permanent injury and shall be recoverable in a civil action by, and paid to, such governmental agency. If more than one such agency has responsibility for the waters in question, the agency which conducts the cleaning or abating activities shall be the agency authorized to proceed under this section.

California's Vehicle Code, section 34500, assigns responsibility for safe operation of trucks carrying hazardous materials to the California Highway Patrol. With one exception, that department has adopted the pertinent Federal regulations. The exception is that poisons cannot be transported on flat-bed vehicles. However, these regulations, as well as regulations promulgated by other state agencies, are not directly aimed at prevention of water pollution. A lessening of inherent pollution danger may be an indirect result, but this is not something considered in formulating the regulations.

Agricultural Regulations: Since California is an important agricultural state, close attention has been given to the regulation of pesticides and herbicides. The water pollution potential of such materials must be considered, because their use is so widespread and the threat to water quality so serious. An accidental discharge of certain pesticides into water could have detrimental effects over a long period of time. Agricultural Code, section 11935, requires that aircraft pest control operators show proof of financial responsibility by furnishing security in an amount not less than $25,000. Such funds could be applied toward damages resulting from an accidental water contamination which occurs, for example, because of a wind shift while spraying.

The publication which contains California's compiled regulations is known as the California Administrative Code. The Department of Agriculture's regulations on agricultural pest control specify the precautions which must be taken in using pest control materials. These precautions are spelled out in Title 3, California Administrative Code, section 3093 (3 Cal. Adm. Code 3092):

> (a) All persons engaged for hire in the business of pest control, when using a method or a material containing any substance known to be harmful to persons, animals, crops, or property, shall exercise reasonable precautions to protect persons, animals, crops and property from damage or contamination, and to confine the material applied substantially to the premises, crops, animals, or things intended to be treated.
>
> (b) Pesticides, or emptied containers or parts thereof, shall not be dumped or left unattended at any place where they may present a hazard to persons, animals, crops, or property, nor disposed of in a manner that may cause injury or contamination.

Records from the Department of Fish and Game indicate that pesticides have been responsible for a large percentage of fish kills in California. Title 3 California Administrative Code 3095(c), which is concerned with protection of animals, states that:

> In applying materials harmful to fish, exercise reasonable precautions to avoid contamination of water containing fish.

Section 3095 was adopted in December 1968. If the term "reasonable precautions" is not sufficient, more specific regulations can be expected. Section 2440 through 2455 of the same title in the Administrative Code regulates the use of injurious herbicides, and have nearly all been issued in 1969 and 1970. This holds true also for sections 2460 through 2465, which deal with other injurious materials, including arsenic compounds, organic phosphorus compounds (parathion, TEPP, EPN), chloropicrin, carbamate compounds, mercury compounds, and chlorinated organic pesticides (DDT, DDD, dieldrin, endrin, toxaphene, heptachlor).

In addition to the above regulations, the Department of Agriculture has promulgated emergency procedures to be observed in case of a pesticide spill. This document includes information on agencies which should be contacted if water is contaminated. Disposal methods are also discussed in terms which take into account the protection of ground and surface water quality. In order to protect ground water, it will probably soon be required that only Class I dump sites--the most restrictive--be used for disposal of used pesticide containers.

In general, no statewide system or organization has been established which is concerned with response to an accidental discharge of a hazardous material. The exceptions are pesticides, as noted above, and oil, which includes petroleum, petroleum products, sludge oil refuse and any other oil or oil-like substance of animal, mineral or vegetable origin. The California Oil Spill Disaster Contingency Plan has not yet been formally adopted, but nevertheless provides the guidelines for response to an oil spill. Most officials feel that a similar plan will be drawn up and adopted for other hazardous materials as the need becomes evident.

The Concept of Negligence: Many court cases in the State of California can be cited to show the relative ease with which liability can be established in cases which involve inherently dangerous conditions or materials. Once something is introduced to the water which is harmful, negligence need not be established. The fact that the water is adversely affected is sufficient to make a case. Expansion on this point may be found in 35 California Jurisprudence (2nd edition). Section 172 under the heading of Negligence states:

> A particularly great quantum of care is required of one who has in his possession or under his control an instrumentality that is dangerous to life, or a dangerous material or energy, such as explosives or highly inflammable matter, corrosive or otherwise dangerous or noxious fluids, fire, electricity, and gas. Persons possessing or having control of such a thing must use every means known, or that would be known on due inquiry, to avoid an accident arising from the dangerous thing...

Section 349, in 36 California Jurisprudence (2nd ed.), discusses ultrahazardous activities. This section states in part:

> The courts of this state recognize the so-called ultra-hazardous activities doctrine... Though one who carries on such an ultrahazardous activity does so with the utmost care to prevent harm, he is liable for any injury or damage resulting from the activity to anyone whose person, land, or chattel

> he should recognize as likely to be harmed by an unpreventable miscarriage of the activity... The theories of negligence, nuisance, and liability for ultrahazardous activities are closely related insofar as they apply to the right of a user of real property to be free from unreasonable invasion of, or unreasonable risk to, use and enjoyment of his property, and the corresponding duty to refrain from causing such invasion or risk.
>
> An activity is ultrahazardous if it (1) necessarily involves a risk of serious harm to the person, land, or chattel of another which cannot be eliminated by the exercise of the utmost care and (2) is not a matter of common usage. It may be ultrahazardous because of the instrumentality used in carrying it on, the nature of the subject, or the condition it creates...

It is therefore recognized, by statute, that the degree of liability, and correspondingly the degree of care which must be exercised, is a direct function of the inherent hazard of the material involved.

State of Louisiana

The primary body responsible for the quality of Louisiana's waters is the Stream Control Commission. This commission has control of waste disposal, public or private, by any person, into any of the waters of the state, in order to prevent pollution which tends to be injurious to the public health, the public welfare, or to aquatic life, fowl, and animals. The Stream Control Commission works with the State Board of Health in supervision of water supplies and the disposal of waste.

Louisiana Water Quality Laws: Title 56, Chapter 3, Louisiana Revised Statutes is most directly concerned with water quality. Part I contains sections on the Stream Control Commission, and Part II deals with drainage of noxious or poisonous substances into natural waterways or canals. Section 1437, in Part I, assigns to the Commissioner of Wild Life and Fisheries the responsibility for enforcement and administration of the rules, regulations, and orders of the Stream Control Commission. It also provides that agents and enforcement officers of the Commission of Wild Life and Fisheries are ex-officio agents and enforcement officers of the Commission.

In Louisiana, as in California, none of the water quality laws were developed for the particular case of an accidental discharge of a hazardous material into water. Although statutes found in Title 56 may apply to such spills, the statutory authority to prosecute has not been tested in the courts. Nevertheless, potentially applicable sections are pointed out here. Section 1440 prohibits illegal discharge of waste and other pollution:

> No person shall discharge or permit to be discharged into any of the waters of the state any waste or any pollution of any kind that will tend to destroy fish or other aquatic life or wild or domestic animals or fowls or to be injurious to the public health or against the public welfare in violation of any rule, order, or regulation of the Commission.

Section 1444 specifies that the penalty for violation of section 1440 shall be a fine of not less than $25 nor more than $1,000 plus costs of prosecution, or imprisonment for not more than one year.

Section 1451 refers specifically to destruction of fish; however, the words "knowingly and wilfull" would seem to prevent use of this section in cases involving accidental discharges. Section 1451 reads:

> No person shall knowingly and wilfully empty or drain or permit to be emptied or drained from any pump, reservoir, well, or oil field into any natural stream of the state any oil, salt water, or noxious or poisonous gases or substances in quantities sufficient to destroy the fish therein.

The penalty for violation, specified in section 1453, is a fine of not less than $100 nor more than $2,000, or imprisonment for 30 days to 3 months.

Until recently, Chapter 1 of Title 56 also contained two relevant sections, 322 and 362. Both read the same:

> In order to prevent the pollution of any of the waters of the state, the killing of fish, or the modification of natural conditions in any way detrimental to the interests of the state, no person shall discharge or permit to be discharged into such waters, any substance which kills fish, or renders the water unfit for the maintenance of the normal fish life characteristic of the waters, or in any way adversely affects the interests of the state. Each separate day upon which a violation of this section occurs constitutes a separate offense.

However, Act Number 404 of the 1970 Louisiana legislature repealed sections 322 and 362, while adding sections 639 through 639.2 to Title 56. These sections define and prohibit water pollution, and specify penalties for violation, as follows:

Section 639. Definition

> "Water Pollution" includes the introduction into state water bodies of any substance in concentration which results in the killing of fish or other aquatic life in numbers or in a manner materially detrimental to the interests of the state or renders the water unfit for maintenance of the normal fish or aquatic life characteristics of the waters, or in any way adversely affects the interests of the state in respect to its fish or other aquatic life.

Section 639.1 Pollution of waters; discharge of injurious substance

> In order to prevent the pollution of any stream or other water body of the state, the killing of fish or other aquatic life, or the modification of natural conditions in any way detrimental to the interests of the state, no person shall knowingly discharge or knowingly permit to be discharged into any waters of the state, or into drains which discharge into such waters, any substance which causes "Water Pollution" as defined in section 639 of this Sub-part, provided, however, that the provisions of this Sub-part shall not apply to any unintentional pollution or contamination resulting from or in connection with the production of agricultural products. Each separate day upon which a violation of this section occurs constitutes a separate offense.

Section 639.2 Penalty for violation of Sub-part

> Whoever intentionally violates any of the provisions of this Sub-part shall be fined for each offense not less than one-hundred dollars nor more than two-thousand dollars or imprisonment for not more than one hundred days or both.

Section 639.2 specifies a more serious penalty than those assessed for repealed sections 322 and 362. However, the use of the word "knowingly" in the new section 639.1 and "intentionally" in 639.2, indicates that the repealed laws were stronger, from the point of view of application to accidental pollution cases. Discussion of relative strengths is probably academic, however, since water quality officials in Louisiana feel that intent must be proven if criminal prosecution is sought using Title 56.

The statutes and record of prosecution for spill in Louisiana reflect a disinclination to seek criminal action in the case of an accidental discharge. There is a decided preference for voluntary cooperation in combatting such problems. Whenever an accidental spill of a hazardous material into water has damaging results, representatives of the Commission of Wild Life and Fisheries try to reach some mutual agreement with the responsible party as to damage costs. Some attempt has been made to assign a value to fish losses, and some consideration given to collection of replacement costs for other aquatic life. In cases where agreement cannot be reached, the state or any individual can seek civil action for damages or injuries suffered. The Stream Control Commission has not sought such an action in the case of an accidental discharge, but Wild Life and Fisheries has done so in cases involving fish kills. In such instances, the District Attorney of the parish in which the pollution occurs has the option to try the case, after considering the charges.

Both managers and lawyers responsible for water quality in Louisiana recognize that voluntary action is not always consistent with the taking of all necessary precautions to prevent accidental discharges and to mitigate damaging effects. They desire to know more about the seriousness of the problem, and feel that stronger statutes would be helpful. Act Number 405 of the 1970 Louisiana legislature, which specifies and clarifies the rights of the state in the event of a pollution of state waters provides an example of a more meaningful law. By this Act, Section 1446 of Title 56 of the Louisiana Revised Statutes was enacted, which reads as follows:

> Section 1446. Pollution of waters; recovery of civil Attorney General to institute action; jurisdiction in District Courts
>
> A. Whenever any person without a certificate of approval, permit or other document of approval authorized by law, or in violation of the terms and conditions of such certificate of approval, permit, or other document of approval authorized by law, has negligently, carelessly or wilfully caused pollution of the waters of the state in such concentration or manner that wild birds, wild quadrupeds, fish or other aquatic life are killed as the result thereof, or renders the water unfit for maintenance of the normal fish

> or aquatic life characteristics of the waters or renders the water unfit for the usages which have been established for the stream or other water body by the commission (Stream Control Commission), the commission may recover, in the name of the state, damages from such person.
>
> B. The commission shall notify the person or persons responsible of the amount of damages claimed by the commission and may effect such settlements as it deems reasonable. If no settlement is reached within 60 days the Attorney General shall bring a civil action in the name of the state to recover the damages, in either the district court of the parish in which the damage has occurred or the district court of the parish in which the State Capitol is located. The district courts shall have jurisdiction to hear and determine such actions.
>
> C. The measure of damages shall be the amount determined by the court to be the replacement cost thereof or the cost of restoring the stream or other water body to its former condition plus the cost of all reasonable and necessary investigations made or caused to be made by the state in connection therewith.
>
> D. No civil proceeding brought under this section shall limit or prevent any other actions or proceedings in respect to the pollution of waters which are authorized by this Part or other provisions of law.
>
> E. The provisions of this Part shall not apply to any unintentional pollution or contamination resulting from or in connection with the production of agricultural products.

To date, statutory authorization to bring civil action for recovery of damages in pollution cases has been granted in only a few states. It seems that section 1446 could readily be applied to accidental spills of hazardous materials. Of course, "negligently" and "carelessly" will by key words, in a test of Louisiana's new civil damage recovery law.

Other Louisiana Laws: Article 2315 of the Louisiana Civil Code was often cited, by officials from the Stream Control Commission and the Attorney General's office, as the basic right of action law for any individual who is damaged. This article states in part:

> Every act whatever of man that causes damage to another obliges him by whose fault it happened to repair it;...

An expansive case history has been built around article 2315. Variations in interpretation occur because of differing circumstances among individual cases. Even though someone who is damaged by water pollution could seek compensation using this article, no cases were related by Louisiana officials where pollution had been caused by an accidental discharge of a hazardous material.

Part II, Chapter 10, Title 3 of the Louisiana Revised Statutes creates an Anhydrous Ammonia Commission. Section 1355 of Title 3 requires bonding for those who handle or manufacture this particular hazardous substance. Before doing business involving anhydrous ammonia, any dealer, manufacturer, or jobber must furnish the commission a bond in the sum of $10,000, as a guarantee that he will comply with provisions and regulations regarding the material.

Section 1627 of Title 3 establishes financial responsibility requirements for applicators of pesticides. It states, in part:

> No license shall be valid, nor shall any license be issued or renewed, unless the applicator shall have filed with the commissioner a corporate surety bond in the minimum amount of $10,000, guaranteeing that the applicator will answer in damages to any person, except the employer, injured by the applicator's pesticide application or drift to plants, animals, or property;... The posting of such bond shall not relieve the person from whom the custom application of pesticides was made from any liability to which he may be subject.

Statewide Contingency Plan: A detailed plan for notification of cognizant state and local officials, in the event of a dangerous discharge, is being developed and disseminated by Louisiana water quality officials. This is consistent with the state's tendency to seek voluntary cooperation on the part of manufacturers, users, and transporters of hazardous materials. Immediate notification is to be tied in with a detailed response plan which will have as a major objective the integrity of the state's waters.

An example of the industry-state cooperation which is being sought is the Waterworks Warning Network Plan for the Lower Mississippi River, dated January 20, 1969. This plan notes that past experience of water deterioration due to accidental industrial discharges indicated the need for a warning system, which was first developed in 1960 with the participation of waterworks people, the State Department of Health, the Stream Control Commission, and industry. In the plan are found specific procedures to be followed in case of a reported discharge, and a listing of responsible people to be contacted. The plan states the anticipation that industry will be the source of information in most cases of accidental discharge.

State of New York

Environmental Conservation Act: On April 22, 1970 the state of New York passed into law an act entitled the Environmental Conservation Law, which completely restructured the enforcement organization for water and air pollution as well as conservation in general. This act abolished the existing Department of Conservation, and incorporated all environment-related functions from other executive departments into a single Department of Environmental Conservation. The department was charged with carrying out the policy of the state of New York, which is:

> ...to conserve, improve and protect its natural resources and environment and control water, land and air pollution, in order to enhance the health, safety and welfare of the people of the state and their overall economic and social well being.

To effectively discharge his responsibilities, the commissioner was given 24 specific responsibilities and powers. Of these powers several have particular applicability to hazardous polluting substances. In brief, the commissioner was given power to:

> ...9. Provide for prevention and abatement of all water, land and air pollution including, but not limited to that related to particulates, gases, dust, vapors, noise, radiation, odor, nutrients and heated liquids.
>
> ..10. Promote control of pests and regulate the use and storage and disposal of pesticides and other chemicals which may be harmful to man, animals, plant life or natural resources.
>
> ..11. Promote control of weeds and aquatic growth, develop methods of prevention and erradication and and regulate herbicides...

> ..13. Prevent pollution through the regulation of the storage, handling and transport of solids, liquids and gases which may cause or contribute to pollution... (emphasis added)
>
> ..24. Exercise and perform such other functions, powers and duties as shall have been or may be from time to time conveyed or imposed by law, including, but not limited to, all the functions, powers and duties assigned and transferred to the department from the department of health, conservation department, department of agriculture and market, and office for local government in the executive department by a chapter or chapters of the laws of nineteen hundred seventy.

The new department thus not only retains all powers of the former organizations but incorporates new powers, some directly related to the control of hazardous materials. The power to regulate storage, handling and transport of solids, liquids and gases which may cause or contribute to pollution demonstrates that the state is aware of the problem of pollution from these sources and is acting to prevent it. Although regulations under the new law have not yet been formulated, recent statements by the commissioner of the new department indicate that the depth of concern stated in the act will be reflected in an active enforcement program. On August 3, 1970, at the opening of a series of hearings on pesticides, the Commissioner made the following statements:

> ...Certain pesticides which persist in our environment or accumulate in organic tissue can cause serious disease and produce long-term detrimental effects among fish, wildlife, and domestic animals--perhaps man. The risk is such that we must act now to protect against this threat.
>
> In preparing the proposed list of restricted use pesticides, we followed two simple guidelines:
>
> If a pesticide is to be used, it must be proven that there is a clear public necessity, and: if introduced into the environment, it must not harm the environment.
>
> Put another way, I believe that the burden must be on those who would introduce an alien substance into the environment to prove that its use will not be harmful--this is in contrast to an earlier philosophy placing the burden on the polluted rather than the polluter...

The enforcement policies in New York state under the new organization, and with the active philosophy reflected above, will be worth watching in the future.

Existing Statutes: For the present, existing statutory law will continue to be enforced until the new regulatory program is formulated. Because the existing statutes are similar to those of other states discussed previously, they will only be summarized here.

The general prohibition against pollution which is found in the Public Health Law is similar to the Federal Refuse Act in that it is a general prohibition against introduction of any organic or inorganic matter that causes or contributes to a condition in contravention of adopted water use standards. This prohibition has been applied by the enforcement arm of the Department of Health. Actual prosecution under the law must be carried out by local district attorneys, although the practice of "compromise," or out of court settlement for damages, is the most common settlement made. In practice, prosecution has only been attempted in cases where negligence can be proven. By statute, emergencies which are caused by "an act of God, war, strike, riot, or other catastrophe as to which negligence or wilful misconduct on the part of such person was not the proximate cause" are specifically excluded from civil and criminal liabilities.

The conservation law provides for the protection of wildlife, and singles out trout streams for specific protection. Spills of hazardous or deleterious materials which occur in designated trout streams are punishable whether a kill occurs or not. Spills in waters other than trout streams are not punishable unless for recovery of specific damages, i.e., killing of fish.

As in some other states, the laws dealing with spills of hazardous materials are rarely tested in the courts. In cases of clear negligence the offender is usually willing to compromise. If negligence is questionable, enforcement authorities are reluctant to prosecute.

State of Ohio

Health Law: Primary pollution abatement authority in Ohio is vested in the Water Pollution Control Board within the Department of Health by the Ohio Water Pollution Control Act of 1951. The Pollution Control Act, as modified in 1967, defines acts of pollution which are prohibited. The appropriate section reads in part:

> Section 6111.04 - Acts of pollution prohibited; exceptions
>
> No person shall cause pollution as defined in division (A) of section 6111.01 of the revised code in any waters of the state, or place or cause to be placed any sewage, industrial waste or other waste in a location where they cause pollution of any waters of the state. Any such action is hereby declared to be a nuisance, except in such cases where the water pollution control board has issued a valid and unexpired permit...

Penalties are imposed for violations, each day of violation after conviction comprising a separate violation. Maximum penalty is a fine not greater than $500 or imprisonment for more than one year or both.

Pollution is thus covered in a general manner, and could apply to some instances of hazardous material spills. From discussions with the assistant attorney general it was determined that prosecution would be attempted only in the event that a nuisance exists, damage occurs, and negligence can be shown. It was believed, however, that no cases had been tried for spills of hazardous polluting substances under the water pollution law.

The Division of Wildlife of the Department of Natural Resources has had some encouraging results from a program instituted under the state's wildlife laws, in many cases involving hazardous material spills. Taking their authority from three sections of the state code, the wildlife division has developed and implemented a program of enforcement which has resulted in reducing fish kills within the state. The First Statute, Section 1531.02 declares state ownership of wildlife. It states in part:

> The ownership of and the title to all wild animals in this state, not legally confined or held by private ownership legally acquired, is in the state, which holds such title in trust for the benefit of all the people. Individual possession shall be obtained only in accordance with the Revised Code or division of wildlife orders...

In the second statute, authority to protect wildlife is stated as a power and duty of the Chief of the Wildlife Divisions:

Section 1531.04

> The Division of Wildlife, at the direction of the Division Chief shall...
>
> (C) Enforce by proper legal action or proceeding, the laws of the state and its orders for the protection, preservation, propagation and management of wild animals and sanctuaries and refuges for the propagation of such wild animals, and adopt and carry into effect such measures as it deems necessary in the performance of its duties.

This enforcement authority is backed up by the stream litter law, section 1531.29 of the wildlife laws. This law states:

> 1531.29 Stream and state land littering prohibited.
>
> No person shall place or dispose of in any manner, any garbage, waste, peelings of vegetables or fruits, rubbish, ashes..oil, or anything else of an unsightly or unsanitary nature on any state owned, controlled or administered land, or in any ditch, stream, river, lake, pond, or other water course, except those waters which do not combine or effect a junction with natural surface or underground waters, or upon the bank thereof where the same is liable to be washed into the water, either by ordinary flow or annual floods...

A fine of not less than 25 nor more than 500 dollars or imprisonment for not more than thirty days may be imposed for violation of the stream litter law.

Using this authority, the Division of Wildlife has established and pursued a program of investigation and prosecution of all cases under their jurisdiction, i.e., spills wherein loss of wildlife occurs. Each reported incident which may involve loss of wildlife is thoroughly investigated by field personnel of the Division of Wildlife. If no significant loss of wildlife occurs, the facts gathered are referred to the water pollution control board. If loss of wildlife valued at greater than $25 occurs, a complete account of all events surrounding the spill is gathered and evidence collected. Fish and wildlife killed are tabulated by size and species, and the total value computed by applying current wholesale value of each. If a sufficiently strong case for conviction can be developed, the case is referred to the Chief Enforcement Officer and the Assistant Attorney General assigned to the wildlife division for action. In practically all cases, the claim, which includes the wholesale value of wildlife lost plus the cost of investigation, is settled out of court.

Although court action is rarely required, enforcement officials feel that the Division's enforcement program has been highly successful as a deterrent to repeated excessive discharges from manufacturing plants and to other intentional spills. Annual loss of fish life has been reduced from 10 million in 1964, when the program was instituted, to less than 1 million in 1969.

State of Pennsylvania

Officials responsible for water quality in Pennsylvania are obviously concerned about problems caused by both accidental and continuous discharges of hazardous materials. This concern has been nurtured by an increasing number of pollution "incident" investigations, and is leading to activity designed to reduce the number of discharges and minimize the chances for injury and damage. A large percentage of accidental spills involve oil and pipelines, but there have been experiences with spills of other materials and different spill conditions.

The Clean Streams Law of Pennsylvania: The water quality laws in Pennsylvania are embodied in the Clean Streams Law, which is found in Title 35 of the Pennsylvania Statutes. The agency administering this law is the Sanitary Water Board in the Department of Health. The Clean Streams Law was amended extensively in 1970 by the General Assembly, with the result that the Sanitary Water Board has, as of July 31, 1970, expanded powers of regulation. Statements made by Sanitary Water Board staff members indicate that this new authority will be used to regulate activities which have the potential for causing water pollution. Quotations from the Clean Streams Law which are cited below will include the recent amendment.

In its definition of industrial waste, section 1 of the Clean Streams Law provides for the inclusion of materials other than those which are usually considered to be waste.

> "Industrial waste" shall be construed to mean any liquid, gaseous, radioactive, solid or other substance, not sewage, resulting from any manufacturing or industry, or from any establishment, as herein defined, and mine drainage, silt,..."Industrial waste" shall include all such substances whether or not generally characterized as waste.

Another definition from section 1 is that of "pollution," which is construed to mean:

> ...contamination of any waters of the Commonwealth such as will create or is likely to create a nuisance or to render such waters harmful, detrimental or injurious to public health, safety or welfare, or to domestic, municipal, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life, including but not limited to such contamination by alteration of the physical, chemical or biological properties of such waters, or change in temperature, taste, color or odor thereof, or the discharge of any liquid, gaseous, radioactive, solid or other substance into such waters...

Section 3 follows up the definition by stating that any pollution is a public nuisance:

> The discharge of sewage or industrial waste or any substance into the waters of this commonwealth, which causes or contributes to pollution as herein defined or creates a danger of such pollution is hereby declared not to be a reasonable or natural use of such waters, to be against public policy and to be a public nuisance.

The 1970 amendment has given the Sanitary Water Board expanded capabilities to adopt rules and regulations, section 5 states, in part:

> ...(b) The board shall have the power and its duty shall be to:
>
> (1) Formulate, adopt, promulgate and repeal such rules and regulations and issue such orders as are necessary to implement the provisions of this act.
>
> (2) Establish policies for effective water quality control and water quality management in the Commonwealth of Pennsylvania and coordinate and be responsible for the development and implementation of comprehensive public water supply, waste management, and other water quality plans...
>
> ...(d) The department (Department of Health) shall have the power and its duty shall be to...

(3) Issue such orders as may be necessary to implement the provisions of this act or the rules and regulations of the board.

(4) Make such inspections of public or private property as are necessary to determine compliance with the provisions of this act, and the rules, regulations, orders or permits issued hereunder.

(5) Report to, and at the direction of, the board.

(6) Perform such other duties as the board may direct.

Water quality officials in Pennsylvania have stated that some of the new regulations which are formulated will deal with the pollution potential due to inadvertant discharges of hazardous materials.

Section 307 of the Clean Streams Law was amended by the recent act to read:

> No person or municipality shall discharge or permit the discharge of industrial wastes in any manner, directly or indirectly, into any of the waters of the Commonwealth unless such discharge is authorized by the rules and regulations of the board or such person or municipality has first obtained a permit from the department...A discharge of industrial wastes without a permit or contrary to the terms and conditions of a permit or contrary to the rules and regulations of the board is hereby declared to be a nuisance.

Article IV of the revised Clean Streams Law indicates Pennsylvania's recognition of the "pollution potential" of various substances. After Section 401 re-emphasizes that it shall be unlawful for any person to discharge any polluting substance into water, Section 402 provides a clear policy on potential pollution.

> Section 402. Potential Pollution - (a) whenever the board finds that any activity, not otherwise requiring a permit under this act, including but not limited to the impounding, handling, storage, transportation, processing or disposing of materials or substances, creates a danger of pollution of the waters of the Commonwealth or that regulation of the activity is necessary to avoid such pollution, the board may, by rule or regulation, require that such activity be conducted only pursuant to a permit issued by the department or may otherwise establish the conditions under

> which such activity shall be conducted, or the board may issue an order to a person or municipality regulating a particular activity...
>
> (b) Whenever a permit is required by rules and regulations issued pursuant to this section, it shall be unlawful for a person or municipality to conduct the activity regulated except pursuant to a permit issued by the department. Conducting such activity without a permit, or contrary to the rules and regulations of the board or conducting an activity contrary to an order issued by the department, is hereby declared to be a nuisance. (Emphasis added)

The sections of Article VI further demonstrate Pennsylvania's resolve to deal with conditions which may lead to water pollution, thereby heading off the actual pollution itself. Regarding abatement of nuisances, section 601 states:

> Any activity or condition declared by this act to be a nuisance, shall be abatable in the manner provided by law or equity for the abatement of public nuisances. In addition, suits to abate such nuisances or suits to restrain or prevent any violation of this act may be in equity or at law in the name of the Commonwealth upon relation of the Attorney General, or upon relation of any district attorney of any county, or upon relation of the solicitor of any municipality affected, after notice has first been served upon the Attorney General of the intention of the district attorney or solicitor to so proceed...

Criminal and civil penalties for violation of the Clean Streams Law are provided for in Sections 602 and 604, respectively. Section 602 reads:

> (a) Any person or municipality who violates any provision of this act or any rule or regulation or order of the board or any order of the department issued pursuant to this act is guilty of a summary offense and, upon conviction, shall be subject to a fine of not less than $100 nor more than $1,000 for each separate offense...
>
> (b) Any person or municipality who, after a conviction in a summary proceeding within two years as above provided, violates any provision of this act or any rule or regulation or order of the board or any order of the department issued pursuant to this act is guilty of a misdemeanor and, upon conviction, shall be subject to a fine of not less than $100 nor more than $5,000 for

> each separate offense or to imprisonment in the county jail for a period of not more than one year, or both...

Section 605, on civil penalties, states:

> In addition to proceeding under any other remedy available at law or in equity for a violation of a provision of this act or a rule or regulation of the board or an order of the department, the board, after hearing, may assess a civil penalty upon a person or municipality for such violation. Such a penalty may be assessed whether or not the violation was wilful. The civil penalty so assessed shall not exceed $10,000, plus $500 for each day of continued violation. In determining the amount of the civil penalty the board shall consider the wilfullness of the violation, damage or injury to the waters of the Commonwealth or their uses, cost of restoration, and other relevant factors... (Emphasis added)

The criminal and civil action provisions of Pennsylvania's amended Clean Streams Law have yet to be tested in the case of an accidental spill of a hazardous material. The extent of the Sanitary Water Board's regulatory authority will probably also be tried at some time in the future.

Pollution Incident Prevention Plan: Even before the 1970 General Assembly amended the Clean Streams Law, the Sanitary Water Board was demonstrating its strong desire to prevent accidental discharges of polluting materials. As a means of combatting at least one important cause of water polluting accidents, the board has instituted a Pollution Incident Prevention Program. In a paper presented at the May, 1970 Purdue Industrial Waste Conference, Donald J. Lazarchik, Director of the Department of Health's Division of Industrial Wastes, discussed this program and cited statistics on pollution incidents which have led to its development. He noted that the Sanitary Water Board had already issued orders to about 350 discharge permit holders, requiring them to submit pollution incident prevention plans.

Each of the Board's orders states that the recipient's industrial waste permit is:

> ...modified so as to require the submission of a plan to prevent accidental discharges of polluting materials. The plan shall consider the consequences of and provide for the prevention of accidental discharges that might occur during the transport, storage, and processing of raw materials and intermediate and

> finished products. The storage and disposal of all solid and liquid waste materials shall be considered in the plan, as well as accidents that may be caused by power failures, floods, or vandalism. The breakdown of treatment plant equipment and other incidents of human failure, facilities failure, and operational failure shall also be considered.

In placing this added requirement on waste permit holders, the board used its authority to specify the conditions which must be met by those seeking and holding industrial waste permits. By issuing such orders, the board was also anticipating the expanded regulatory and preventive authority provided to it by the 1970 General Assembly.

Mr. Lazarchik noted in his waste conference paper, that such orders are calling "industry's attention to its already existing legal and moral responsibility to protect the public by preventing accidents." It might also be said that the initial Pollution Incident Prevention orders reflected the Sanitary Water Board's impatience with a pollution abatement authority which began only after an incident had occurred.

In addition to Pollution Incident Prevention (PIP) orders, which modify existing permits, all industrial waste applications submitted after January 1, 1970, must include a plan for the prevention of accidental discharges. All PIP plans must include details on back-up equipment, maintenance and inspection, prevention training programs, contingency plans, external factors, and a pollution incident history. Arrangements must be made for prompt availability of cleanup services and equipment. Responsibility for notification of downstream water users and the Health Department must be detailed in the plan, together with a list of persons to be notified.

PIP directives are quite explicit as to the level of detail required. They state, for example, that special attention should be devoted to the receiving, transporting, storing and shipping of liquids since such materials can easily reach a watercourse or pollute underground waters. Other specifications require that the direction of flow of spilled liquids should be predicted, that hazardous materials stored in drums in outdoor locations should be routinely patrolled, and that containers should be inspected for detection of leaks.

In his paper, Mr. Lazarchik brought out that, during the past seven years, there have been at least 496 accidents, spills, or intentional dumping of pollutional materials that have killed fish in Pennsylvania streams. He then stated that these cases only represented spills serious enough to kill fish, and which were noticed by someone who reported them for investigation by the Department of Health and the Pennsylvania Fish Commission. These incidents do not include the hundreds of occurrences of tastes and odors in public water supply, the temporary discoloration of receiving streams, and other adverse effects that may not kill fish.

Pennsylvania Fish Laws: Since a fish kill is by far the most common tangible result of an accidental pollution, the Pennsylvania Fish Commission has taken the lead in efforts to take actions against responsible parties. Sections 200 through 203 of the Fish Law (Title 30, Pennsylvania Statutes) provide the Fish Commission with its authority to take criminal or civil action. Section 200 states, in part:

> ...No person shall allow any substance of any kind or character, deleterious, destructive or poisonous to fish, to be turned into or allowed to run, flow, wash or be emptied into any waters within this Commonwealth, *unless it is shown to the satisfaction of the Commission or to the proper courts that every reasonable and practicable means has been used to abate and prevent the pollution of waters in question by the escape of deleterious substances*. (Emphasis added)

Fish Commission officials feel that the portion which is underlined diminishes the effectiveness of the law, and would like to see it deleted. Even so, it is significant that the burden is on the polluter to prove that every means was taken to prevent the pollution, rather than on the state to prove the opposite.

Section 202 prescribes the criminal penalty for violation of section 200:

> Any person violating the preceding provisions of this article shall, on conviction as provided in chapter 14 of this act, be sentenced to pay a fine of not less than $100 nor more than $1000.

Using the argument that the state did not own the fish, a court ruling denied the right of the Fish Commission to bring civil action for a fish kill. Because of this, section 202.1 was added to the Fish Law. This section states:

> (a) The Commonwealth in its sovereign capacity as the guardian and trustee for the people of Pennsylvania of

> all the natural resources of Pennsylvania, including fish and aquatic life, is hereby declared to have sufficient interest in said fish, and aquatic animals living in a free state to give it standing, through its duly authorized agencies, to recover damages in civil action against any person or persons who unlawfully or negligently kill or otherwise destroy any fish or other aquatic animals by pollution.
>
> (b) The proprietary ownership, jurisdiction over and control of fish and aquatic animals living free in nature, including bait-fish and fish-bait, as defined in this act, are hereby declared to have been achieved through the continual expenditure of Commonwealth funds and efforts to protect, perpetuate, propagate and maintain populations of fish, bait-fish and fish-bait within the waters of this Commonwealth as a renewable natural resource of the Commonwealth.
>
> (c) The Fish Commission, as an agency of the Commonwealth duly authorized to regulate, control, manage, and perpetrate the fish and other aquatic life in the waters of the Commonwealth may, in addition to criminal penalties provided in this act, bring civil suits in trespass on behalf of the Commonwealth for the value of any fish, bait-fish or fish-bait, destroyed in violation of Section 200 of this act.

Section 203, which addresses the problem of a sufficient evidence, states:

> In prosecutions under this article for the pollution of waters by substances known to be injurious to fish or to fish food, it shall not be necessary to prove that such substances have actually caused the death of any particular fish.

Because establishment of a specific causal relationship between pollution and damage is usually a difficult problem in prosecution, Section 203 is very significant.

In most cases, the Fish Commission and the party responsible for the pollution will agree on a fair price before any court proceeding is necessary, or while the case is in the courts. The basis for settlement in the past has been some value assigned to each fish killed, by size and specie. It is the Fish Commission's desire to also begin recovering for loss of food chain organisms and the costs of investigation. The civil action provision of the Fish Law should soon be getting its first court test, using a case in which a train derailment caused phenol and acid to enter the water in such quantitites that fish were killed for a distance of 50 miles.

Private Rights of Action

The right of the citizen to take action to recover damages is presently based on either State or Common Law rights provided by State statute.

Common Law Principles

The basic right of action for the citizen is the recovery of damages to his person or property as a result of the action of another person. Such recovery of damages is carried out in civil action in a court of law. In a civil action the plaintiff must show, to the satisfaction of the court, that damage did occur, and that it was caused by the negligent or intentional action of the defendent. An example of this kind of action in reference to hazardous materials is found in Nelson v. C & C Plywood 462 P2d 314 (1970), Montana Supreme Court. In this case, a homeowner recovered damages when glue from a factory's waste ditches polluted his water well. Another case where the common law principles applied is Owens v. U.S. 294 F. Supp 400 (1968). Here the complaining party received damages for government negligence in the application of pesticides, which allegedly polluted a creek and a cattle pond. In this situation the complaining party was required to show that the government failed to exercise the degree of care required under the circumstances, and that this failure was the direct cause of the damages.

The primary limitations in civil actions under common law are that damages must have occurred and must be proven with certainty, and that action may be brought only by the damaged party. Unless provided by statute, a citizen may not bring suit against a violation of public property or property of another person. Similarly, in bringing civil action against a polluter, the government must be able to show that public property owned, or held in trust by the state (e.g., wildlife), is damaged. In a recent lower court action in Pennsylvania, a civil court denied the state's claim for a fish kill, saying that the state did not own the fish and therefore could not bring action to recover damages. This situation was subsequently rectified when a statute was added to the state law verifying the application of the trust doctrine in the case of wildlife, and assuring that in future cases the state could prove ownership of fish in state waters. In some states, as in California, common law precedents have established state ownership of wildlife, obviating a need for a statute to that effect.

Another right of action available to the citizen is the mandamus action. This is basically the right to force a public official to perform his duties. If a citizen feels that a public official is not carrying out his responsibilities to the public, an action may be brought to force him to do his job. Although this kind of action is rarely applied, and is difficult to win, it is a means for the citizen to take action in jurisdictions where the responsible officials are clearly not using the authority they have to correct violations against the public interest.

Statutory Law

Statutory law applied to spills of hazardous materials is primarily directed toward protecting those waters and lands of the state which are held in trust for the public by the government. Offenses committed which violate statutory law may be prosecuted through criminal proceeding or through civil action as provided for in the law. In general, only the state may bring action to abate a pollution which affects only the public welfare. Two exceptions may be noted. The first is the qui tam right, which gives a citizen the right to bring action for violation of a statutory law when the citizen has a monetary interest in the proceedings, such as a reward provided by statute.

The Refuse Act of 1899 provides for the award of one-half of the penalty collected for prosecution under the Act to the person reporting the offense to the government. Because of this monetary interest, the citizen reporting the pollution may have the right, under the qui tam principle, to bring civil action against the polluter and, if successful, to recover his due portion of the penalty assessed. Several recent cases under the Refuse Act by citizens have been filed using this theory, but no conclusive precedent on the availability of this remedy has yet been decided. Many lawyers feel that courts will rule adversely to this citizen-action theory. Second, according to a lawyer working for California's Attorney General, any person aggrieved by the actions or inaction of the Water Resources Control Board, in carrying out its obligation to protect the public interest, may himself institute civil proceedings for recovery of damages. This right is provided by statute to allow the citizens of a state additional latitude in dealing with a particular problem, such as pollution. Actions are not generally sought, however, because of the cost involved and the problem of providing sufficient proof that a particular incident has led to pollution. Michigan has recently passed a statute allowing a citizen broad authority to sue to abate pollution.

The right of a citizen to bring an action to abate pollution without showing specific damage to himself ought to be granted under the Refuse Act in both State and Federal law. The qui tam theory should not be expanded. Rather, class action rights should be authorized with no monetary rewards provided to the plaintiff, other than the recovery of costs when he prevails. This is particularly true when the prosecution of hazardous polluting substances (spill cases) is so inadequate at both the State and Federal level. Any damages recovered would go into funds established to effect environmental restoration in the event cleanup or restoration at a specific spill site were impossible or undesirable.

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6 Title
CONTROL OF SPILLAGE OF HAZARDOUS POLLUTING SUBSTANCES

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27 Abstract An evaluation of the water quality aspects germane to the spillage of hazardous polluting substances is developed. Emphasis is placed on definition and classification of chemical materials; the nature of the sources of spillage and past experience; and analysis of the relative threat to water quality offered by such substances; a review of presently available detection, control, and removal technology; relationship to water quality standards; and the relevant administrative, enforcement, and cost recovery aspects. Over 800 chemical substances were evaluated as to their annual production and transport quantities, their critical concentration in the aquatic environment resulting in water quality impairment for the several beneficial water uses, detection limits (both field and laboratory), and the control and removal methods presently available or potentially practicable. Over 250 chemicals and compounds, generally those in large scale production and utilization, are priority ranked in order of relative threat to water quality in terms of annual production/sales, intrinsic hazard to water quality, transport mode, and past statistical accident frequency. Recommendations are presented regarding future research and development efforts aimed at mitigating damage and a consensus of informed parties is presented relating to the need for additional legislation. This report fulfills Contract No. 14-12-866, between the Federal Water Quality Administration and the Pacific Northwest Laboratories, Battelle Memorial Institute.

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